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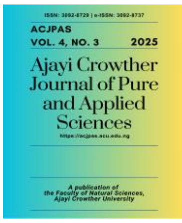

Article

Lorenz Equation and Its Applications on the Impacts of Climate Change on Human Activities in the Tropical Zones

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Abstract

Climate change casts a long shadow across the globe, and its effects are particularly severe for human activities concentrated in the tropics. Understanding these impacts are the keys to crafting effective strategies to lessen the damage and adjust to the changing environment. Through this study, we aim to investigate the impacts of climate change on human activities particularly on agriculture, water availability and health issues. We utilize the Lorenz equation to simulate the behavior of a simplified climate system, taking into account the use of fourth order Runge-Kutta method (RK4) and ode45 for numerical solutions via the use of MATLAB software package. By incorporating the RK4 and ode45 methods, we can numerically solve the Lorenz equations and capture the complex dynamics of the climate system. The sensitivity analysis was conducted on three key parameters. Through our sensitivity analysis, we can understand how variations in these parameters can impact the behavior of the climate system and subsequently influence human activities in the tropics. A detailed study of these three parameters reveals that climatic systems are very unpredictable. Increased convection might lead to changes in rainfall patterns, impacting water availability for agriculture and potentially influencing drought or flood risks. While the Lorenz model is a simplified system, it is still a very effective tool in understanding how climatic systems such as the tropical climate system works.

Keywords: Climate Change, Human activities, Lorenz Equation, Simulation and MATLAB.

1. Introduction

Over the years, various efforts have been considered into the study and development of suitable mathematical models for climate change. The United Nations Framework Convention on Climate Change (UNFCC) in 1992 defined climate change as a change that is attributed directly or indirectly to human activities that alter the composition of the atmosphere globally over a comparable period of time leading to an increase in average temperatures, this is primarily induced by increase in greenhouse gases such as carbon dioxide (CO_2) [10]. The evolution and industrialization of man, have brought about vast disadvantages to the earth of which include climate change. This problem is caused by the emission of greenhouse gases which are composed of harmful gases such as methane, carbon dioxide, and so on. Findings have shown that about 83% of the emission of greenhouse gases is caused by human activities [6]. Climate change, propelled by human activities, has emerged as a defining global challenge, transcending geographical boundaries and impacting ecosystems and societies on a profound scale [11]. Understanding and quantifying the intricate impacts of climate change on human activities in tropical regions requires comprehensive models that encapsulate the complex interplay of atmospheric dynamics [1].

In this study, it is intended to emphasize the need of understanding and mitigating the impacts of climate change on human activities in the tropics. Through an exploration of the Lorenz model, we seek not only to contribute to scientific knowledge but also to offer tangible solution for the challenges faced by communities in tropical regions navigating the complexities of a changing climate. According to Lorenz 1963, he propounded the Lorenz model which was rooted in chaos theory and renowned for its simplicity, emerges as a promising tool for dissecting the dynamics of climate variability [5]. While the Lorenz model may not capture the full complexity of climate systems, its ability to reveal fundamental behaviors and sensitivities make it an invaluable instrument for exploring the localized impacts faced by tropical communities [2].

2. The Mathematical Model

The mathematical model that is used in this study is the Lorenz model. The relevance of the Lorenz model in the tropics lies in its capacity to simulate climatic condition specific to those regions. By tailoring the model's parameters to represent factors like convection and regional climate patterns, it is possible to bridge the gap between theoretical models and the lived experiences of communities in tropical climates [3]. In addition, the model will assist to investigate the impacts of the Prandtl number, Rayleigh number and the Aspect ratio on the appearance and behavior of chaotic systems. Also, we shall run a simulation to help study specific trends in climate change and temperature variation in the tropics with the understanding the impacts of temperature change on agriculture, water availability and health matters in the tropics.

The mathematical model is governed by the following Lorenz equation [4]:

$$\frac{dx}{dt} = \sigma(y - x); \qquad x(t_0) = x_0 \tag{2.1}$$

$$\frac{dy}{dt} = \rho x - y - xz, \qquad y(t_0) = y_0 \tag{2.2}$$

$$\frac{dz}{dt} = xy - \beta z; \qquad z(t_0) = z_0 \tag{2.3}$$

where $x_0 = 1;\ y_0 = 1;\ z_0 = 1;\ t_0 = 0$, as the initial conditions of the system of equation [4].

The equations relate the properties of a two-dimensional fluid layer uniformly warmed from below and cooled from above. Particularly, these equations describe the rate of change of three variables – x, y, z with respect to time:

$\boldsymbol{x}$ is the rate of convection with respect to time - essentially this is the transfer of heat through the movement of fluids. "x" is influenced by the interaction of other variables ("y" and "z") representing simplified aspects of buoyancy and vertical flow [8].

$\boldsymbol{y}$ is the horizontal temperature variation with respect to time. Changes in "y" reflect variations in energy transfer and the generation of vorticity (angular rotational movement in fluid) within the system [9].

z is the vertical temperature variation - essentially these measures how different the top-to-bottom temperature profile is from a straight line. Higher "z" values might indicate regions with stronger upward motion and potential for warmer temperatures (relative to the baseline), while lower "z" values might suggest stronger downward motion and potentially cooler regions [7].

sigma ($\boldsymbol{\sigma}$) known as Prandtl number is the ratio of the viscosity of the air to its thermal conductivity.

rho (ρ) known as Rayleigh number is the difference in temperature between the bottom and top of the box - It essentially captures the relative importance of buoyancy forces (due to temperature differences) compared to viscous dissipation forces (that resist flow) within the modeled system.

beta (β) known as Aspect Ratio is the ratio of the width of the box to its height.

t is the time.

3. Results and Discussion

Using the MATLAB software package to solve and simulate on equations (2.1 – 2.3) taking the original values used for the Lorenz equation with the sustained initial conditions, we obtain the following results and the graphs. When $\sigma = 10$, $\rho = 28$, $\beta = \frac{8}{3}$, we obtain the Figure 3.1.

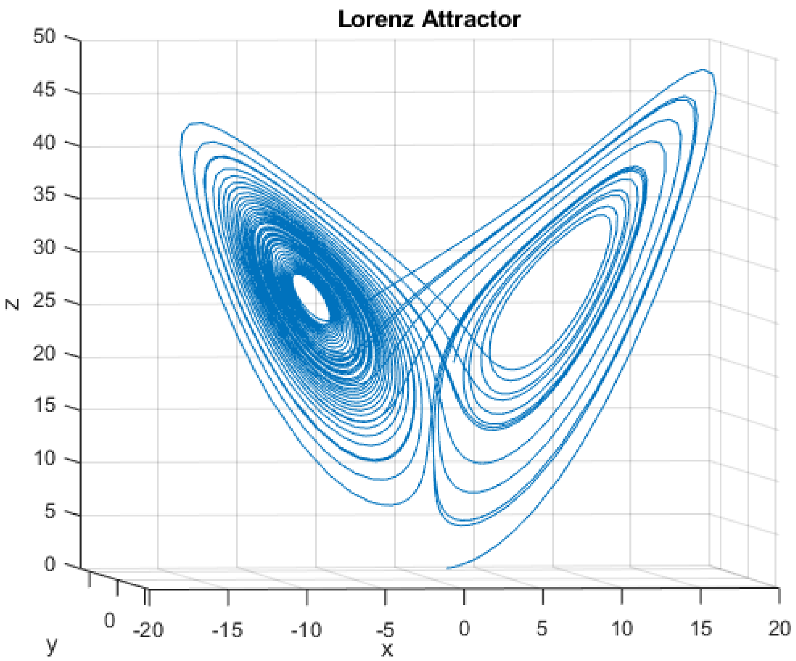
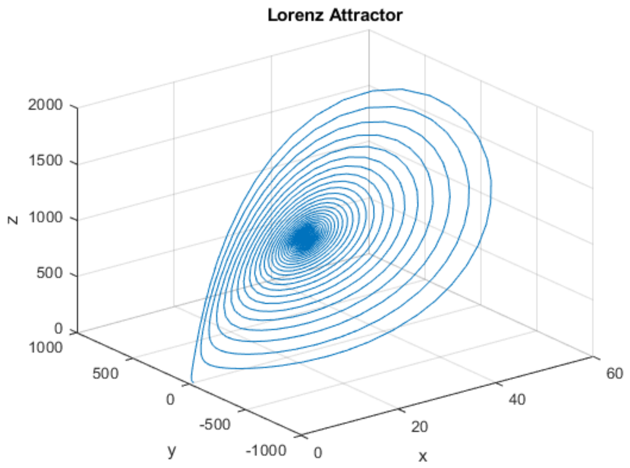


Figure 3.1: The Butterfly Attractor

Taking the Tropical Zones into account in this simulation, it is important to assume a range of values for these parameters which resemble real-world values.

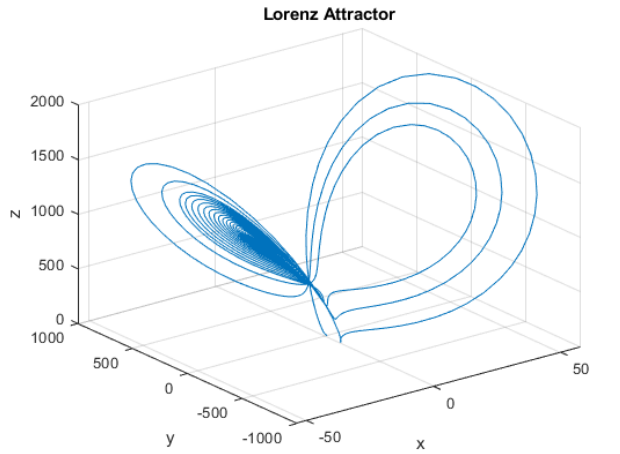
A test is required to study how different values for each of the three parameters reacts to the system, this section begins the observation of the behavior of the system as a result of change in the values of sigma. Starting with Sigma which is also known as the Prandtl Number, we assume a range of values for sigma, such that, $0.1 \leq \sigma \leq 2.0$. It is important to use values with small step sizes to show how very little changes in a parameter affects the whole system. In this study, a step size of 0.2 was used.

Fig. 3.2 shows that the system exhibits a stable reaction at sigma = 0.7. The system exhibits a stable reaction as the values for sigma decreases. The system exhibits an unstable reaction as the values for sigma increases. At values, 1.3, 1.5, and 1.7, it is evident that the system exhibits significant changes but the plots have similar appearances. In Summary, A higher value of sigma leads to faster changes in the variables, resulting in a more chaotic and unpredictable system. This increased chaos and unpredictability can be observed in the trajectory of the system's variables. A lower value of sigma, on the other hand, leads to slower changes in the variables and a more stable and predictable system.



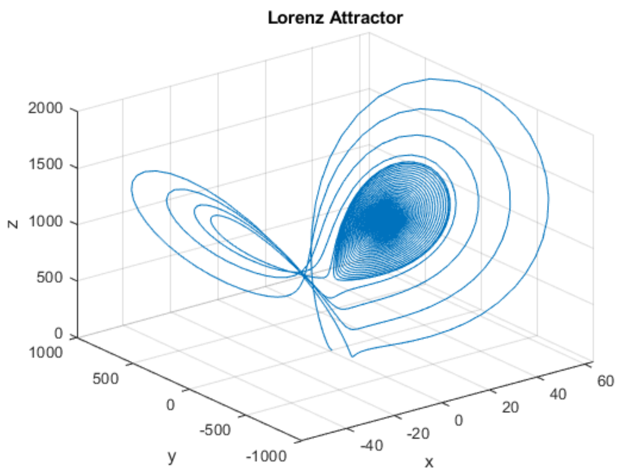
$\sigma = 0.7, \rho = 10^3, \beta = 0.6$

Fig. 3.2: Appearance of the system for $\boldsymbol{\sigma = 0.7}$



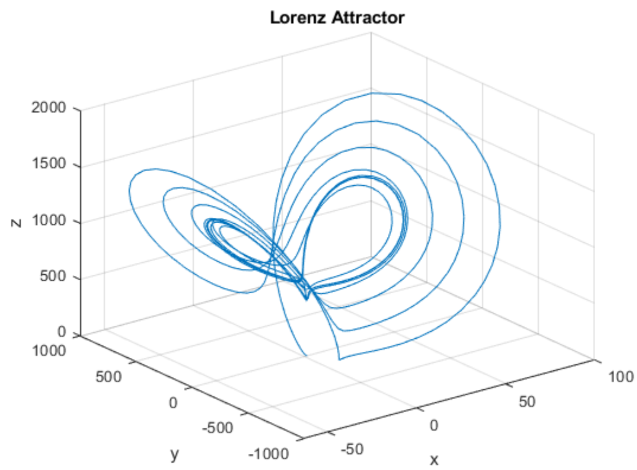
$\sigma = 0.9, \rho = 10^3, \beta = 0.6$

Fig. 3.3: Appearance of the system for $\boldsymbol{\sigma = 0.9}$



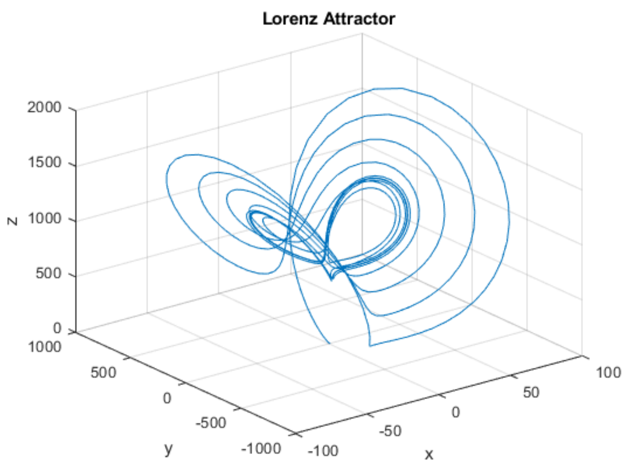
$\sigma = 1.1, \rho = 10^3, \beta = 0.6$

Fig. 3.4: Appearance of the system for $\boldsymbol{\sigma = 1.1}$



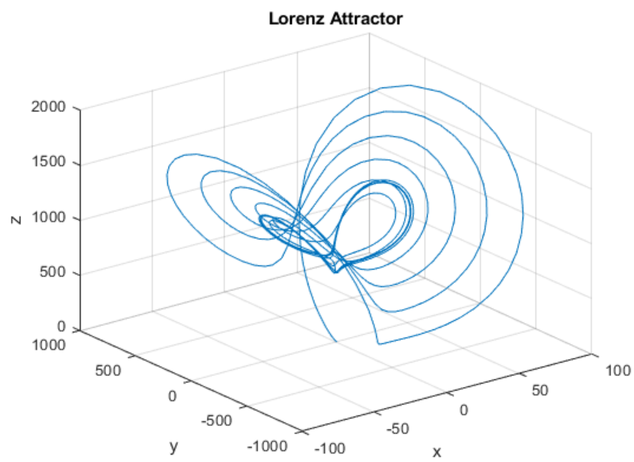
$\sigma = 1.3, \rho = 10^3, \beta = 0.6$

Fig. 3.5: Appearance of the system for $\boldsymbol{\sigma = 1.3}$



$\sigma = 1.5, \rho = 10^3, \beta = 0.6$

Fig. 3.6: Appearance of the system for $\boldsymbol{\sigma = 1.5}$



$\sigma = 1.7, \rho = 10^3, \beta = 0.6$

Fig. 3.7: Appearance of the system for $\boldsymbol{\sigma = 1.7}$

The figures below are the results of the analysis which investigates the influence of the Prandtl number (represented by sigma, σ) on the behavior of the z-component within the Lorenz model. The z-component typically reflects deviations from a baseline temperature state within the modelled system. The analysis involves plotting the z-component's variation over time for different values of sigma.

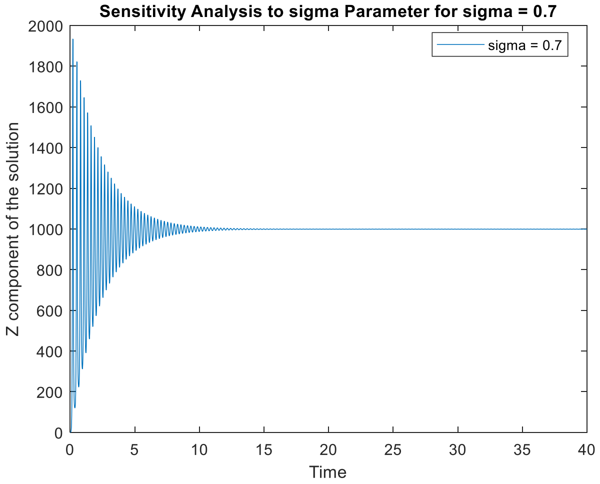


Fig. 3.8: Sensitivity analysis to $\sigma = 0.7$

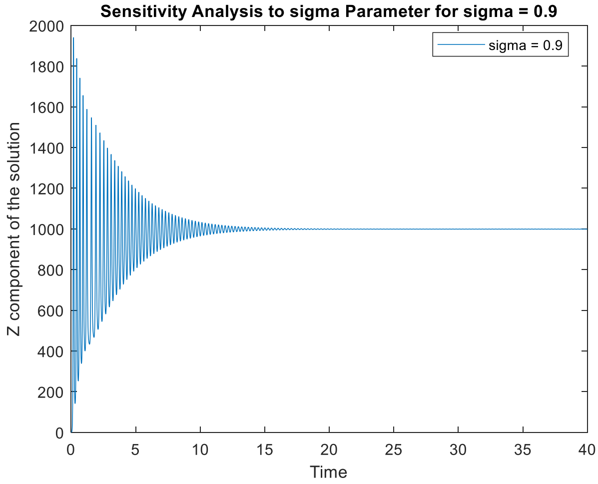


Fig. 3.9: Sensitivity analysis to $\sigma = 0.9$

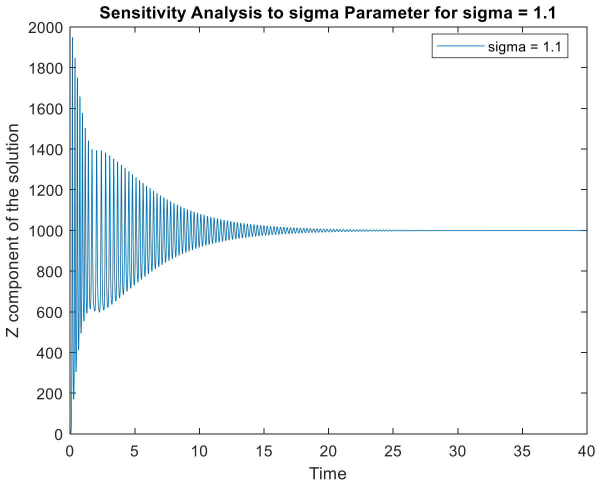


Fig. 3.10 Sensitivity analysis to $\sigma = 1.1$

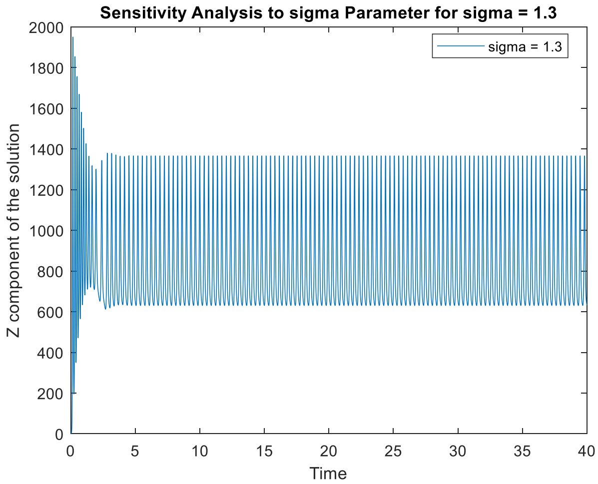


Fig. 3.11 Sensitivity analysis to $\sigma = 1.3$

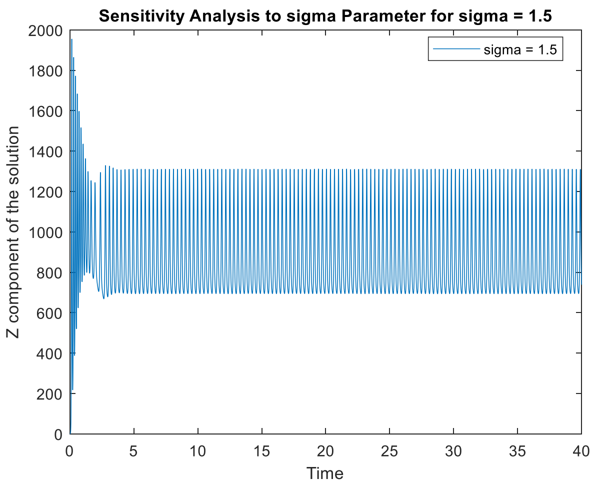


Fig. 3.12: Sensitivity analysis to $\sigma = 1.5$

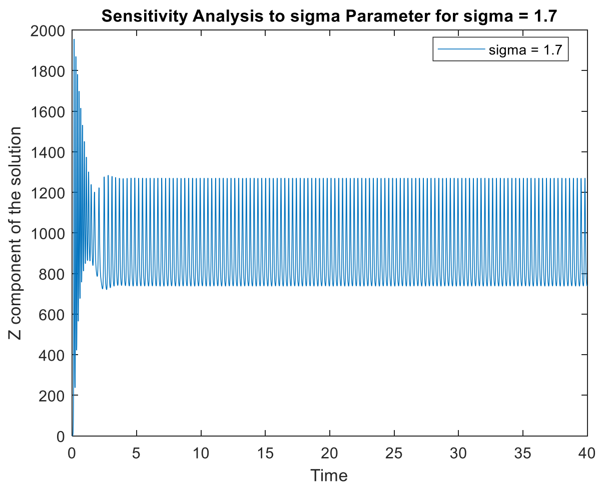


Fig. 3.13: Sensitivity analysis to $\sigma = 1.7$

As shown in Fig. 3.8, where Sigma = 0.7, it is observed that as time approaches ≥ 5 the system exhibits a transition or a form of stabilization in its behavior approaching that time, that is, when t ≥ 5. This may be due to transition to a stable regime, damping of chaotic behavior, influence of system parameters and Transient dynamics (this implies that the stability may just be for a short period). Starting at points 1.3, 1.5, and finally 1.7, the system becomes very unstable, which can be expressed through the appearance of the plots. This supports the fact that system reacts unstably as sigma increases. A progressive increase in the value of sigma, influences the behavior and chaotic flow of the system. In all cases, at the origin point, the system starts as being chaotic and either reaches a point of stability over time if there is a decrease in the value of sigma or continues as a chaotic system if there is a progressive increase in the value of sigma.

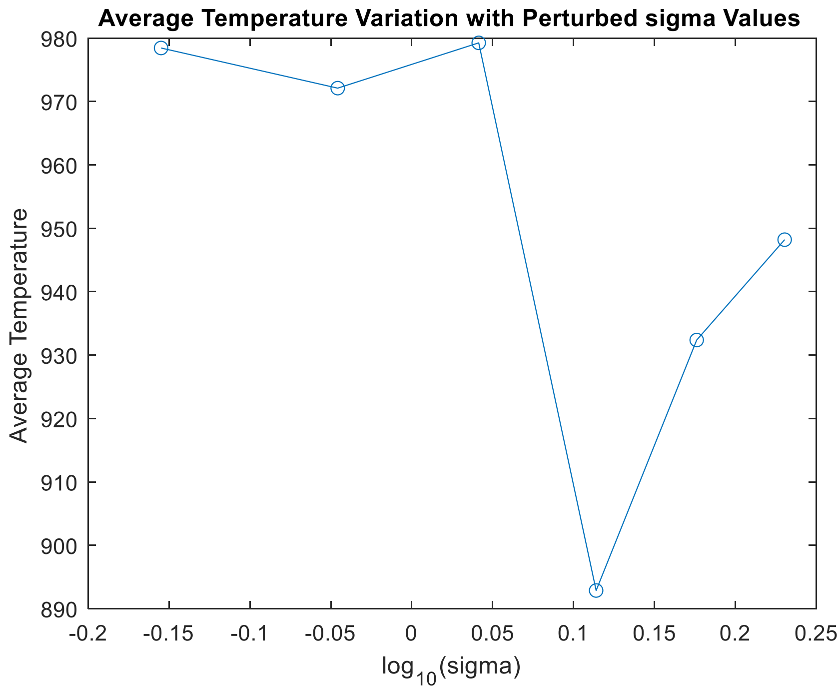


Fig. 3.14: Average Temperature Values with Perturbed Sigma Values

3.1 Effects of Prandtl Number (Sigma, σ) on Human Activities – Agriculture, Water Availability, and Health

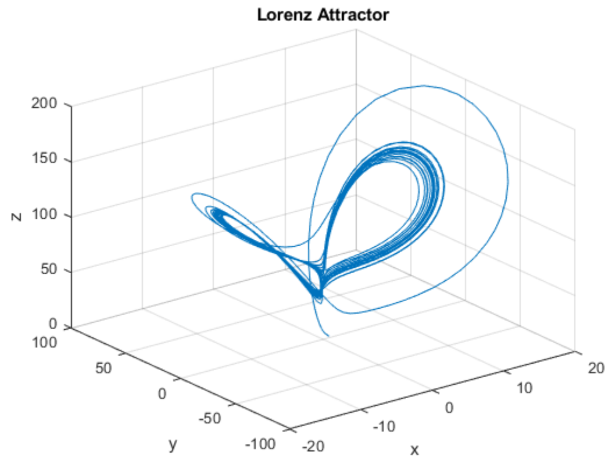
From the graph 3.1 above lower values of sigma were characterized by high temperatures but as sigma increased a massive drop in temperature was noticed. A lower Prandtl number (sigma) signifies stronger heat transfer compared to momentum transfer. This can lead to more vigorous convection within the model, potentially influencing:

1. **Precipitation patterns:** Increased convection signifies stronger upward motion of air. This stronger lift allows more moisture to be transported higher into the atmosphere. This might lead to changes in rainfall patterns indicating increased rainfall in most cases, impacting water availability for agriculture and potentially influencing drought or flood risks.

2. **Temperature variations:** More vigorous convection could affect temperature distribution within the model, potentially influencing growing seasons and crop yields in agriculture.

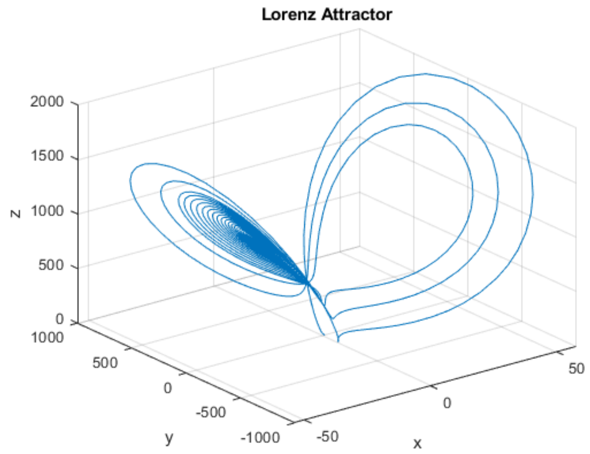
3.1.1 Observations and Sensitivity Analysis of Rayleigh Number (rho, ρ)

For rho which is also known as the Rayleigh Number, we assume a range of values for rho, such that: $10 \leq \rho \leq 10^6$. It is important to use values with small step sizes to show how very little changes in a parameter affect the whole system. In this study, a step size of 0.5 was used. Firstly, a test for the systems reaction to the change in the rho values would be carried out, then, a sensitivity analysis would be carried out thereafter.



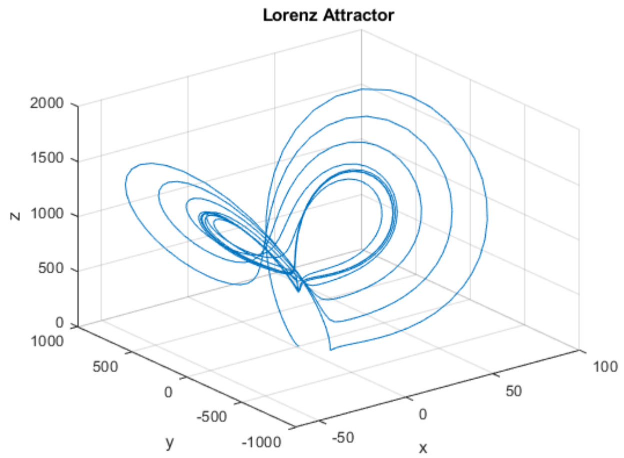
$\sigma = 1.3, \rho = 10^2, \beta = 0.6$

Fig. 3.15: Appearance of the system for $\rho = 10^2$



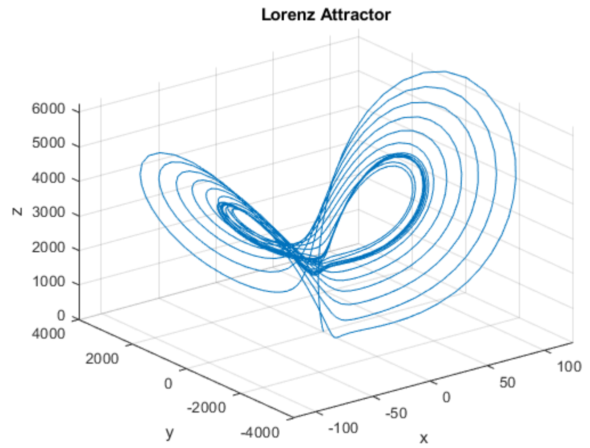
$\sigma = 1.3, \rho = 10^{2.5}, \beta = 0.6$

Fig. 3.16: Appearance of the system for $\rho = 10^{2.5}$



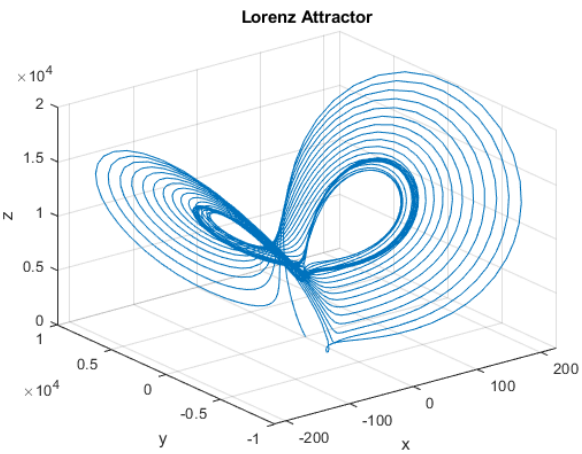
$\sigma = 1.3, \rho = 10^3, \beta = 0.6$

Fig. 3.17: Appearance of the system for $\rho = 10^3$



$\sigma = 1.3, \rho = 10^{3.5}, \beta = 0.6$

Fig. 3.18: Appearance of the system for $\rho = 10^{3.5}$



$\sigma = 1.3, \rho = 10^4, \beta = 0.6$

Fig. 3.19: Appearance of the system for $\rho = 10^4$

The appearance of the system starts as being chaotic and highly unpredictable. Even slight variations in rho can dramatically alter the system's behavior, suggesting a strong influence of rho on the system's dynamics. The system’s appearance shows no sign of stability at any value change which could indicate that rho is a principal factor in the instability of the system. At rho = 10^4, the system is highly unstable compared to previous values used in the analysis. This could indicate that the appearance of the system is most unstable as rho increases. This section focuses on the results of a sensitivity analysis conducted on the Lorenz model, specifically investigating the influence of the Rayleigh number (rho) on the behavior of the vertical component (z) over time.

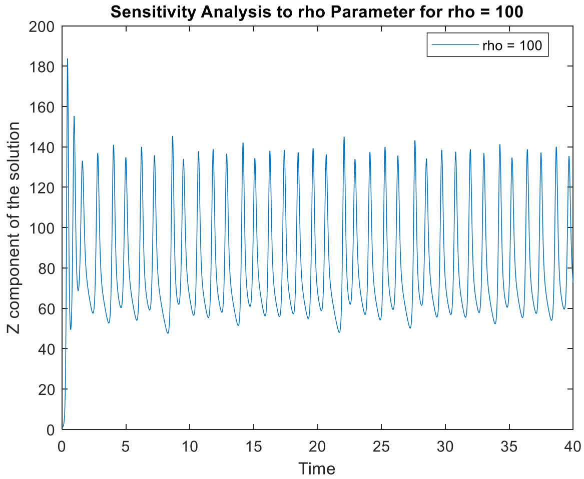


Fig. 3.20: Sensitivity analysis to $\rho = 10^2$

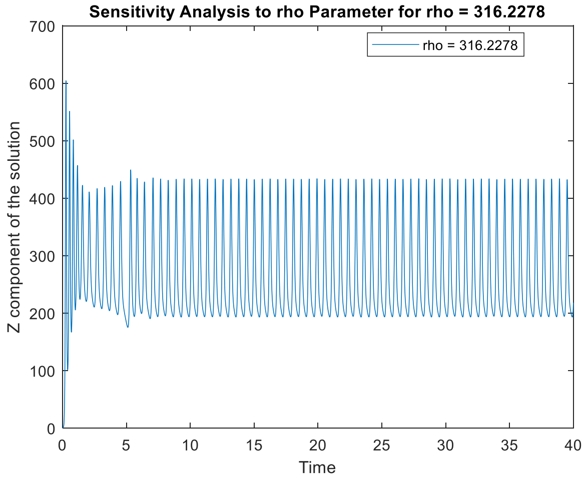


Fig. 3.21: Sensitivity analysis to $\rho = 10^{2.5}$

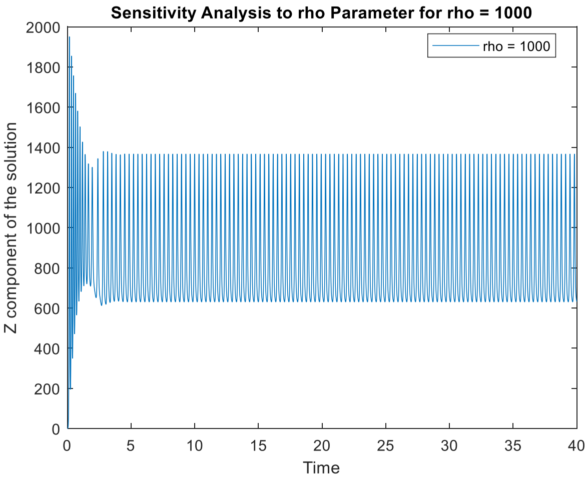


Fig. 3.22: Sensitivity analysis to $\rho = 10^3$

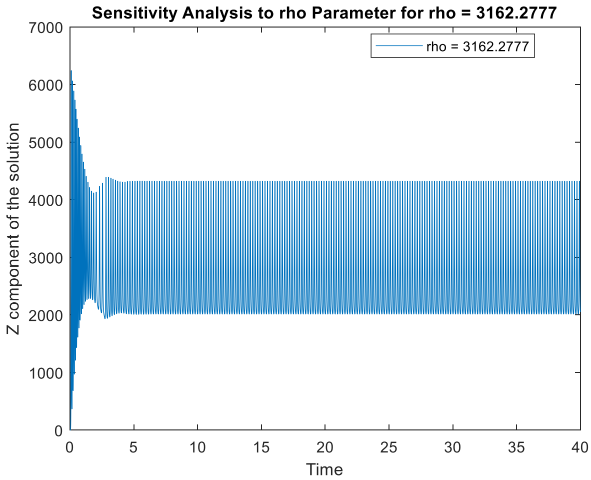


Fig. 3.23: Sensitivity analysis to $\rho = 10^{3.5}$

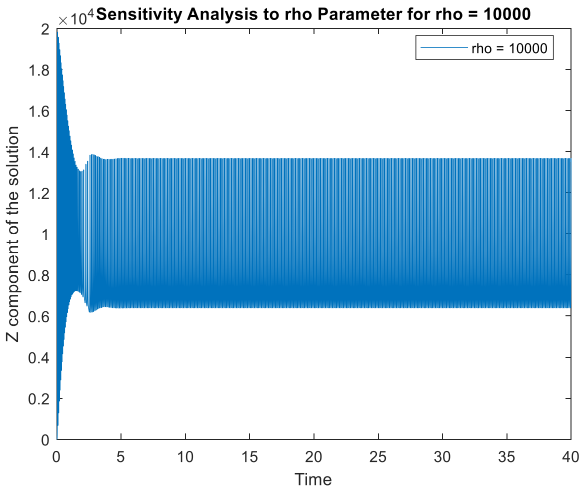


Fig. 3.24: Sensitivity analysis to $\rho = 10^4$

The analysis starts at rho = 10^2, The plot appears sparse while exhibiting instability. As the value for rho increases, the plot seems to get clogged together indicating an increase in chaotic behavior. At rho = 10^3, the plot begins to get closely packed together indicating highly chaotic behavior. When rho is large ($\geq 10^3$), the system tends to exhibit more chaotic behavior, with trajectories in the phase space becoming densely packed and highly sensitive to initial conditions. The system as indicated in the plot, is highly sensitive to rho. The plot shows highly unpredictable behavior with a change in values for rho.

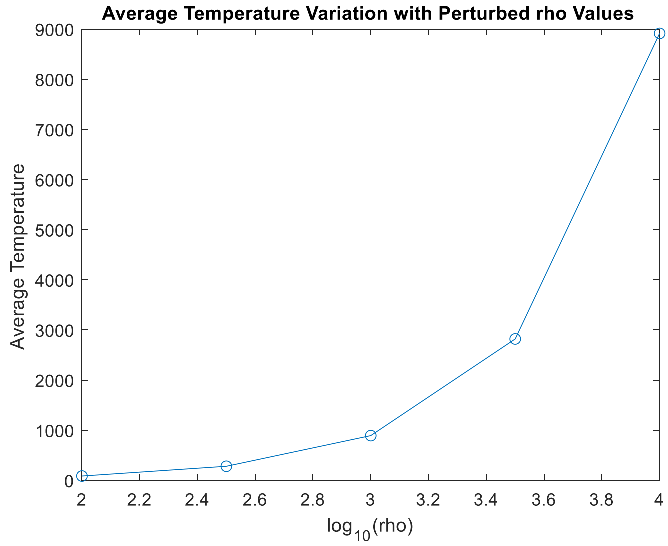


Fig. 3.25: Average Temperature Values with Perturbed Rho Values

3.2 Effects of Rayleigh Number (rho) on Human Activities – Agriculture, Water Availability, and Health Issues

Rho measures the strength of buoyancy forces relative to viscous dissipation. Higher rho indicates increase in temperature and stronger convection, meaning warmer air parcels rise faster, leading to more vigorous atmospheric circulation. Rho impacts human activities in the following ways:

1. **Temperature extremes:** Stronger convection might contribute to more frequent heatwaves and temperature fluctuations, impacting crop growth and stressing agricultural ecosystems.

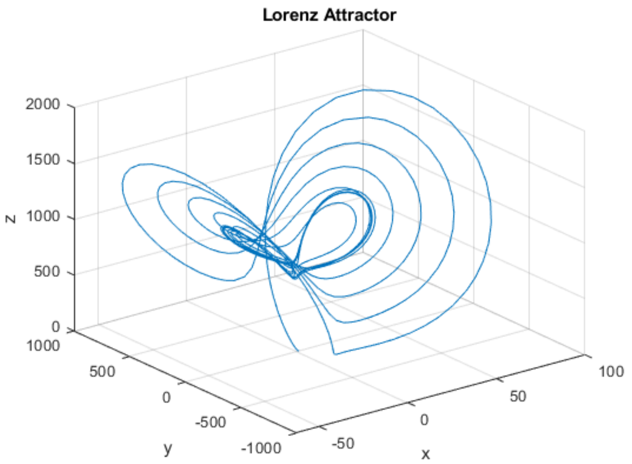
2. **Uneven distribution:** Increased convection could lead to areas with excessive rainfall causing floods and soil erosion, while other regions might experience drought due to changes in circulation patterns. This necessitates improved water management infrastructure and drought-resistant agricultural practices.

3. **Spread of vector-borne diseases:** Changes in temperature and humidity due to altered convection patterns might favor the development and spread of mosquito-borne diseases like malaria and dengue fever, which are already prevalent in the tropics.

4. **Heat stress:** More frequent heatwaves can lead to heatstroke, dehydration, and other health problems, especially for vulnerable populations like children and the elderly.

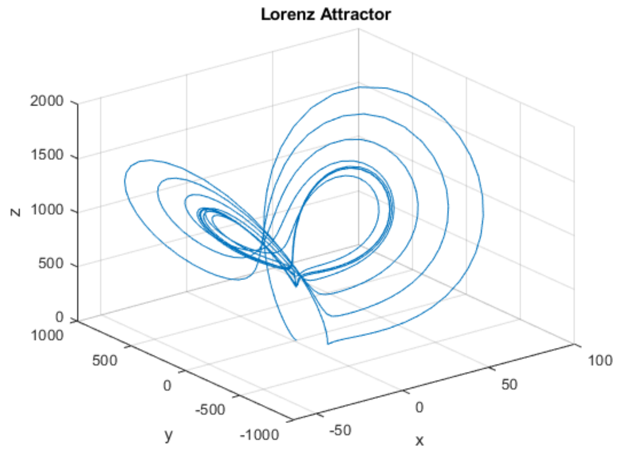
3.2.1 Observations and Sensitivity Analysis of Aspect Ratio (beta, β)

Beta which is also known as the Aspect Ratio, we assume a range of values for beta, such that: $\mathbf{0.2 \leq \boldsymbol{\beta} \leq 1.}$ It is important to use values with small step sizes to show how very little changes in a parameter affect the whole system. In this study, a step size of 0.2 was used. Firstly, a test for the system's reaction to the change in the beta values. Then, a sensitivity analysis would be carried out thereafter.



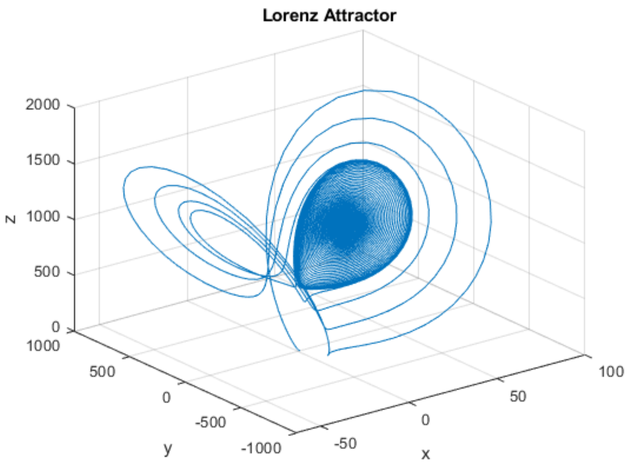
$\sigma = 1.3, \rho = 10^3, \beta = 0.4$

Fig. 3.26: Appearance of the system for $\beta = 0.4$



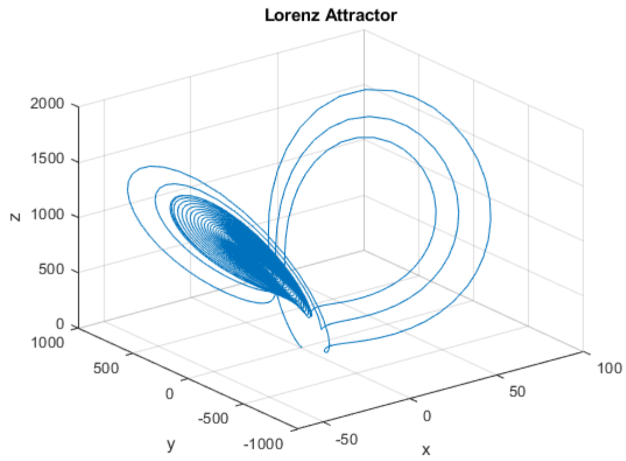
$\sigma = 1.3, \rho = 10^3, \beta = 0.6$

Fig. 3.27: Appearance of the system for $\beta = 0.6$



$\sigma = 1.3, \rho = 10^3, \beta = 0.8$

Fig. 3.28: Appearance of the system for $\beta = 0.8$



$\sigma = 1.3, \rho = 10^3, \beta = 1$

Fig. 3.29: Appearance of the system for $\beta = 1.0$

At the starting value, where beta = 0.4, the system appears unstable. When a step size of 0.2 is added to the starting value, the system still appears chaotic. As the value gets to 0.8 and 1, the system appears to react quite strangely, that is, circling itself at the right side of the 3D plot, almost as if wrapping itself up to an origin point like forming a circular structure, while still keeping its chaotic appearance, speculating that both a chaotic or non-chaotic behavior exists in the system simultaneously. The system appears to exhibit chaotic behavior as the value for beta decreases.

This section focuses on the results of a sensitivity analysis conducted on the Lorenz model, specifically investigating the influence of the Rayleigh number (rho) on the behavior of the vertical component (z) over time.

The system is very sensitive to small values of beta. The system is highly chaotic at 0.6 than at 0.4 which could suggest that the stability of the system may not be just subjected to a decrease in the value of beta. There may be some range of values with which beta exhibits highly chaotic behaviors compared to others. Beta shows the most unpredictable behavior among the three parameters of the study. At beta = 0.8 and 1, the system starts as being chaotic. However, as t approaches 10 the system begins to reach a point of stability. The system is most sensitive at beta = 0.6.

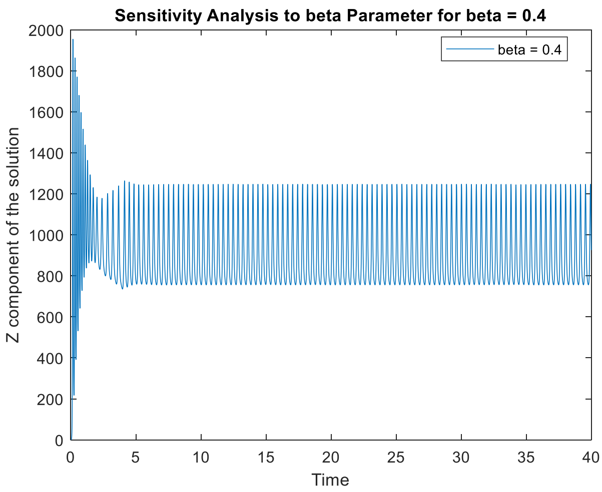


Fig. 3.30: Sensitivity analysis to $\beta = 0.4$

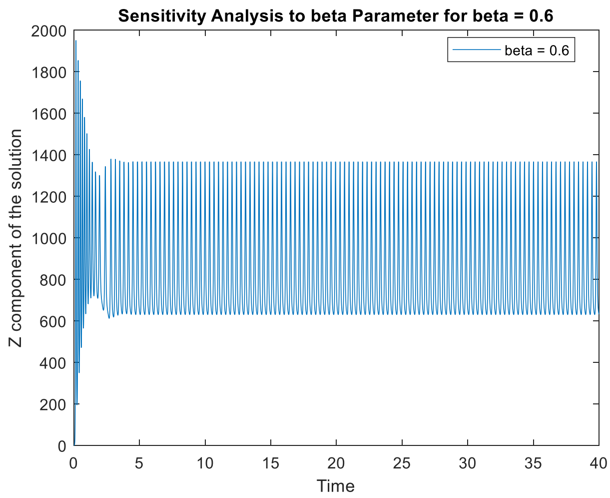


Fig. 3.31: Sensitivity analysis to $\beta = 0.6$

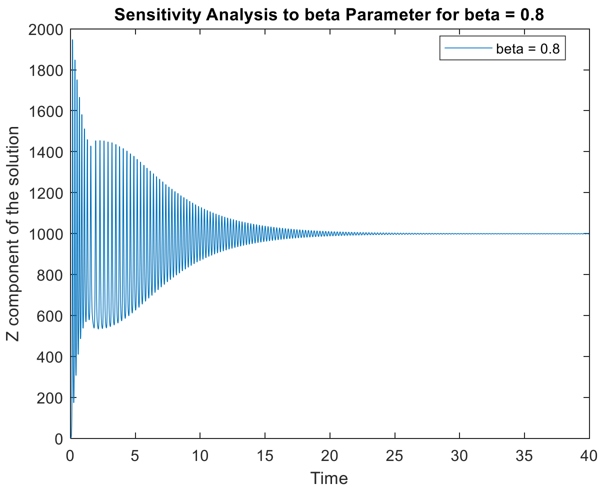


Fig. 3.32: Sensitivity analysis to $\beta = 0.8$

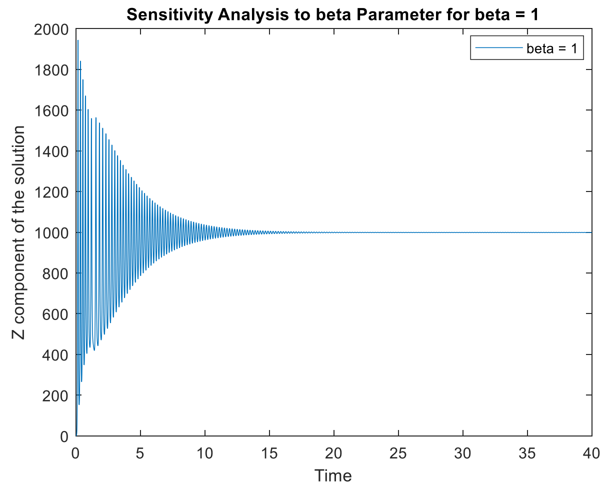


Fig. 3.33: Sensitivity analysis to $\beta = 1.0$

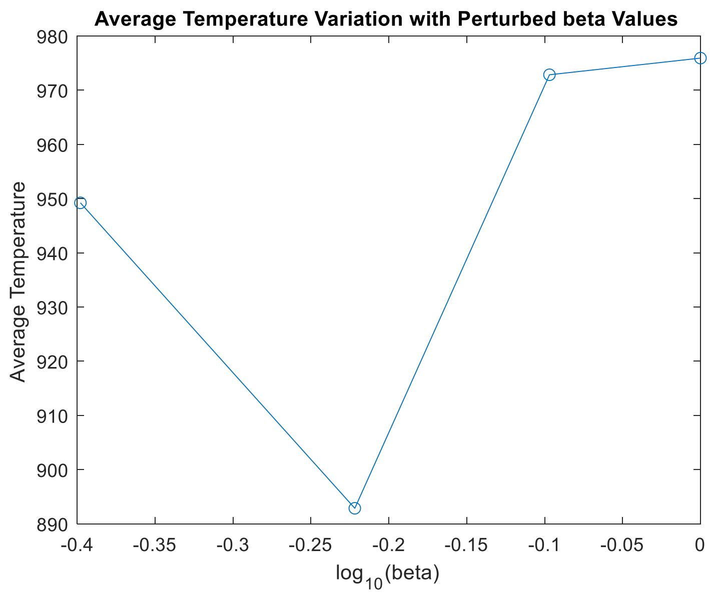


Fig. 3.34: Average Temperature Values with Perturbed Beta Values

3.3 Effects of Aspect Ratio (Beta) on Human Activities – Agriculture, Water Availability, and Health issues

Aspect ratio (beta) represents the ratio of the horizontal side length to the vertical side length of the model's spatial domain. It influences the size and intensity of convection cells within the model, which can indirectly affect simulated variables like precipitation patterns. Beta impacts human activities in the following ways:

1. **Potential Trends:** In the Lorenz model, a higher aspect ratio (taller domain) might lead to stronger vertical convection cells, potentially affecting precipitation patterns. This could indicate:

   a. Increased precipitation in some regions (convergence zones)
   b. Decreased precipitation in others (divergence zones)
   c. Shifts in precipitation patterns over time

2. **Indirect Effects:** Changes in water availability (precipitation patterns) simulated by the model can indirectly affect agricultural productivity.

3. **Complexities:** The link between aspect ratio in the Lorenz model and health is particularly complex. It requires considering potential changes in:

a. **Vector-borne diseases:** Mosquitoes and other disease vectors might be affected by changes in temperature and humidity linked to altered precipitation patterns.

b. **Waterborne diseases:** Changes in water availability can impact access to clean water and sanitation, potentially influencing disease outbreaks.

3.4 Effects of Prandtl Number, Rayleigh Number, and Aspect ratio on the Average Temperature Variations.

Average Temperature Variation for Prandtl Number (sigma)	Average Temperature Variation for Rayleigh Number (rho) with it calibrated values.	Average Temperature Variation for Aspect Ratio (beta)
978.4366	86.650450 (0.1963°C)	949.2137
972.1025	281.209598 (0.6370°C)	892.8676
979.2475	892.867559 (2.0226°C)	972.8411
892.8676	2820.666219 (6.3898°C)	975.9118
932.3748	8915.362679 (20.1963°C)	N/A
948.2047	N/A	N/A

N/A – not applicable

1. There is no specific pattern or arithmetic/geometric progression in the rise and fall of temperature variation for each parameter which indicates chaotic behavior.

2. There is no predictable behavior in the values for temperature variation for each parameter.

3. The average temperature increases substantially as the parameter rho is increased, suggesting a strong sensitivity of the system's temperature to changes in rho.

4. A fluctuation in temperature is noticed with variation in the Prandtl number and aspect ratio.

5. A lower Prandtl number indicates that thermal diffusivity is higher relative to momentum diffusivity. This means heat can spread through the fluid faster, leading to a more even distribution of temperature. Conversely, a higher Prandtl number signifies that momentum diffusivity is higher than thermal diffusivity. Heat transfer is then dominated by the movement of the fluid itself, potentially leading to localized hot and cold regions. This explains the reason for the fluctuation in temperature.

3.5 Effects of Increased Temperature Variation on Human Activities – Agriculture, Water Availability and Diseases.

Agriculture:

1. **Reduced crop yields:** Higher temperatures can stress crops, leading to stunted growth, reduced pollination, and increased susceptibility to pests and diseases. This can significantly impact food security in tropical regions.

2. **Changes in growing seasons:** Warmer temperatures might shift planting and harvesting windows, potentially disrupting traditional agricultural practices.

3. **Salinization:** Rising sea levels due to climate change can lead to saltwater intrusion into coastal agricultural lands, rendering them unusable.

Water Availability:

1. **Increased evaporation:** Higher temperatures lead to faster evaporation from water bodies, rivers, and soil, reducing overall freshwater availability.

2. **Changes in precipitation patterns:** While some areas might experience increased rainfall, others might face droughts. This erratic pattern can disrupt water management strategies.

3. **Glacier retreat:** Mountain glaciers in tropical regions are melting at an alarming rate, reducing a crucial source of freshwater for rivers and irrigation systems.

Disease Outbreak:

1. **Expansion of vector habitats:** Warmer temperatures can expand the geographical range of disease-carrying insects like mosquitoes, allowing them to thrive in new areas. This can increase the risk of vector-borne diseases like malaria, dengue fever, and Zika.

2. **Faster pathogen reproduction:** Higher temperatures can accelerate the life cycle of some pathogens, potentially leading to faster transmission and larger outbreaks of diseases.

3. **Changes in water quality:** Warmer temperatures can promote the growth of harmful bacteria and algae in water bodies, leading to waterborne illnesses.

4. Conclusion

This study utilized the Lorenz model to explore how variations in atmospheric parameters might influence tropical climate and potentially impact human activities such as Agriculture, water availability and health. It also gives insights on how some temperature patterns can impact these human activities. The analysis focused on three key parameters: Prandtl number (sigma), Rayleigh number (rho), and aspect ratio. The results suggest that changes in these parameters can affect temperature patterns within the model.

In this study, the Z component was assumed to be the temperature variation. In the sensitivity analysis section, the Z component was plotted with respect to time and each parameter was tested to study how little changes in the initial conditions of the parameter affect the Z component concerning time. To fully study the temperature variations, a graph for the effect of each parameter on the Z component with respect to time was averaged and plotted. Simulated temperature values are scaled or normalized to represent relative changes in temperature rather than absolute values.

The result of these methods suggests that the Rayleigh number is a key factor in the increase in temperature, while, the other parameters are characterized by fluctuation in temperature. After studying how increase in temperature variation "Z" (which is greatly influenced by the increase in Rayleigh number and decrease in Prandtl number) affects the case study human activities in the tropical regions. The rising temperatures (due to increased rho and decreased sigma) could lead to decreased agricultural yields, increased water stress, and a higher risk of vector-borne diseases in tropical regions. These insights can inform adaptation strategies and highlight areas for further research on climate change mitigation and its human consequences.

5. Recommendations

Based on this study, we recommend that research and development efforts should be focused on climate-resilient crops, improved water management technologies, and early warning systems specifically tailored to the needs of tropical regions should be supported. It is also required that, community-based healthcare initiatives that focus on vector-borne diseases and heat-related illnesses should be developed. This could involve promoting the use of mosquito nets, improving sanitation infrastructure, and raising awareness about heatstroke prevention.

References

1. Ayoola, S. O., Idowu, A. A., Opele, A. I., and Ikenweiwe, N. B. (2011). Impact of Climate Change in Nigeria. *Iranica Journal of Energy and Enviroment,* 2: 145-152.
2. Corlett, R. T. (2014). Impacts of Climate Change in the Tropics. *State of the Tropics* 2: 155-161.
3. Huang, P., Xie, S.-P., Hu, K., Huang, g., and Huang, R. (2013). Patterns of the seasonal response of tropical rainfall to global warming. *Nature Geoscience* 6(5), 357-361.
4. Lorenz, E. (1963). Deterministic Nonperiodic Flow. *Journal of Atmospheric Science*, 20(2): 130-141.
5. Lorenz, E. N. (1976). Nondeterministic Theories of Climatic Change. *Quartenery Research*, 6(4): 495 - 506.
6. Mandal, S., Islam, M. S., Akter, S., and Biswas, M. H. (2020). A Mathematical Model to Investigate the Frequent Impact of Global Warming on Coastal Lives. 1-12
7. Palmer, T. N. (1993). Extended-Range Atmospheric Prediction and the Lorenz Model. *Bulletin of American Meteorological Society*, 74(1): 49-66.
8. 8. Shen, B.-W., Piekle, R. A., Sr, Zeng, X., and Zeng, X. (2023). Lorenz's View on the Predictability Limit of the Atmosphere. Encyclopedia, 887-889.
9. Singh, R. B., and Singh, O. (2012). Study of Impacts of Global Warming on Climate Change: Rise in Sea Level and Disaster Frequency. In R. B. Singh, O. Singh, and R. B. Singh (Ed.), Global Warming: Impacts and Future Perspective pp. 93-198.
10. UNFCCC. (1992). United Nations Framework Convention on Climate Change. United Nations 1-25.
11. Watts, M., Hutton, C., Mata Guel, E. O., Suckall, N., and S.-H.Peh, K. (2022). Impacts of climate change on tropical agroforestry systems: A systematic review for identifying future research priorities. Frontiers in Forests and Global Change, 5:1-19.

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