Land Surface – Atmosphere Interaction

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Land-use types and environmental circumstances in South Africa were determined based on energy budget, soil attributes, and vegetation.

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1. Introduction

Land usage and land cover changes can be influenced directly by the climate system. It leads to biochemical and biophysical processes (1). Moisture content, plant coverage, surface change, and time length are some of its physical features. Other influences included absorption, emission, and radiation from the environment (2-4). Energy and water, on the other hand, had a significant part in climate change (8-9). Climate change is becoming more prevalent these days, causing widespread anxiety (1-3). Land cover changes are occurring globally as a result of economic expansion and population, and they are linked to climate change and atmospheric conditions (7-9).

Many studies have attempted to pinpoint climate change in South African areas, although the majority of them have focused on precipitation and temperature (5-6).

However, we focused on heat flux and sensible heat flux, with land modification as a contributing factor. Botswana is a sub-region of South Africa that we are studying. Then we look at how energy flow has changed between 2003 and 2019. Finally, we constructed a climate graphic to show how average temperature and precipitation have changed throughout time.

2. Aim

The goal of this study is to examine precipitation, evaporation, temperature differences, latent heat flow, sensible heat flux, and leaf area index in the South Africa region between 2003 and 2019.

3. Study Area

The study area is centred on the continent of South Africa. Botswana has been chosen as the location. The main data is divided into 11 categories based on the kind of land cover. Use QGIS Desktop 3.24.0 to have a better understanding of the region. Figure 1 depicts land cover categories based on ESRI data, such as water, trees, vegetation, crops, developed area, and others.

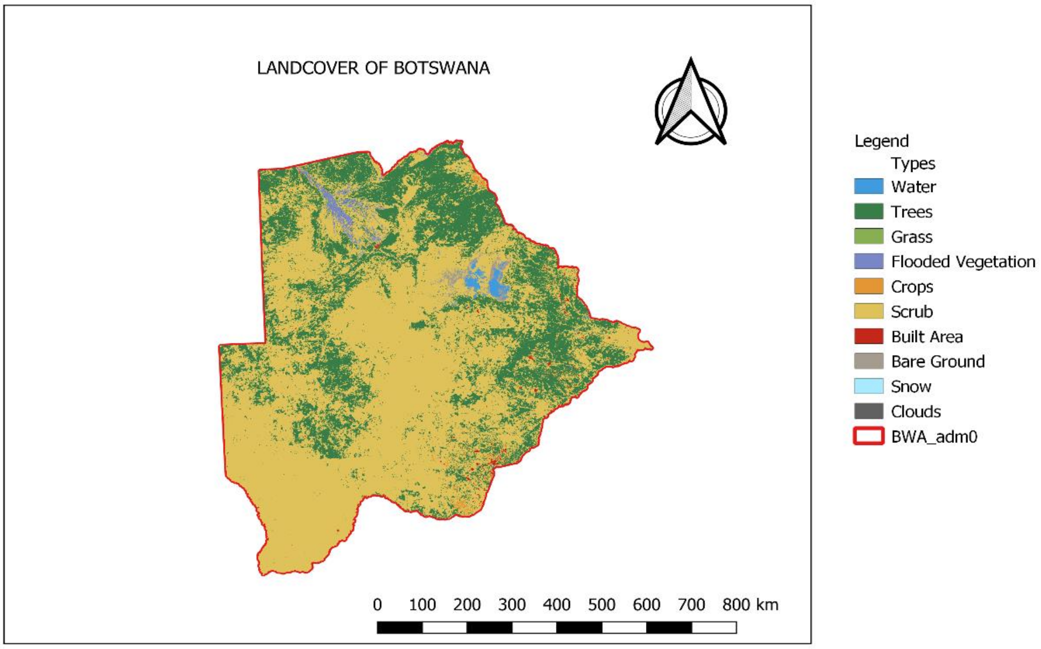

Figure 1: Land Cover categories of Botswana

4. Materials and Methods

The data analysis in this study was done with Spyder (anaconda3). The ERA5 was used to collect the daily data. For the spatial data, DIVA-GIS, an open data source, was used. For the land cover study, QGIS 3.24.0 was used, and the raster file was downloaded from Esri 2020. Finally, NASA GISS gathered data from the HOSEA KUTAKO INTL.A, WA area station. Yearly data was collected for analysis from 1966 to 2021. The average precipitation, evaporation, temperature, and leaf area index were compared and identified between the two years in this study.

5. Land Cover Classes Analysis and Characterize

ECMWF produced the most significant climate data, which is called ERA5. It basically provides the hourly data of atmospheric, land-surface and sea state parameters. ERA5 data are available in the climate data store on regular latitude-longitude grids. The analysis is focused on a sub-area of Botswana and covers Longitude 22° to 26°, Latitude -20° to -24°.

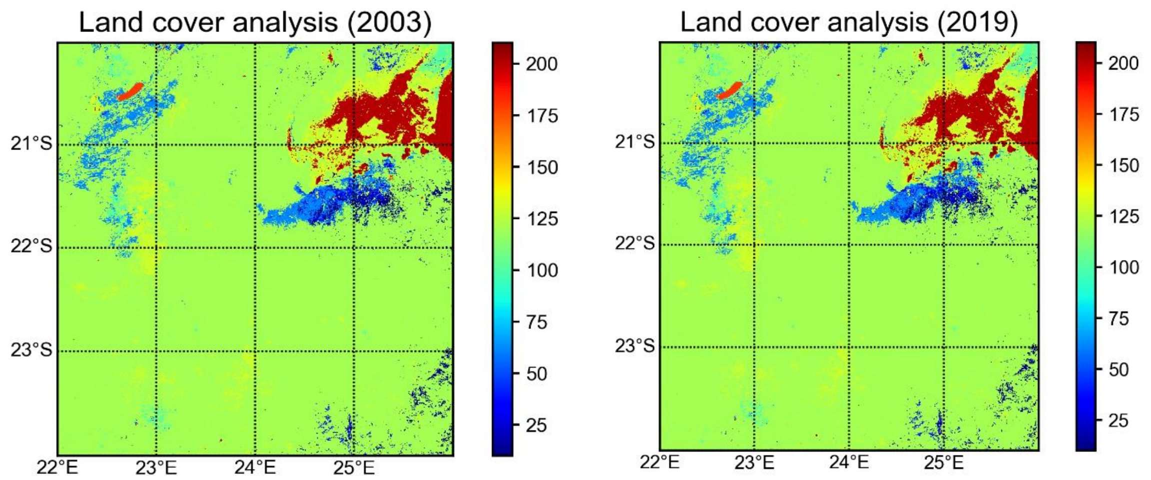

Figure 2: Land Cover Classes of Botswana in 2003 and 2019

Figure 2 shows the changes in land cover between 2003 and 2019. According to the figures, areas remain the same with a slight grassland shift and water bodies.

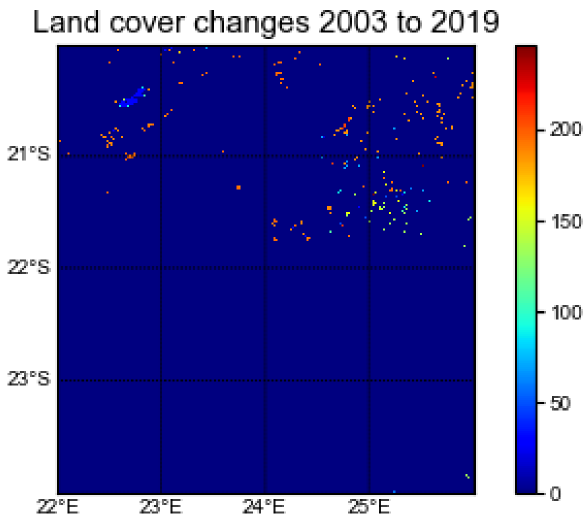

Figure 3: Land Cover Changes Between 2003 and 2019

Figure 3 shows how the terrain has changed over the last sixteen years. Changes in water bodies, crops, and vegetation are depicted in the diagram. This might occur due to differences in precipitation, evaporation, and temperature between these years.

6.Climate Diagram of Zone

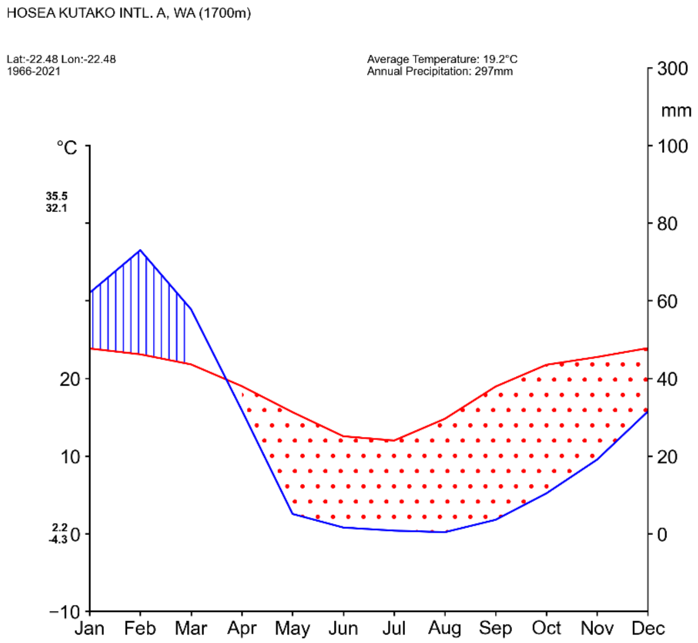

Figure 4: Climate Data Analysis of Namibia Africa

Figure 4 show the climate diagram of the Namibia zone. There is no climate station in the Botswana region, so try to identify the nearest station in this area. So in -22.48° latitude and -22.48° longitude, find the HOSEA KUTAKO INTL.A, WA station. The station is a semi-arid region, as it has annual rainfall is less than 20 inches. We collected 55 years of precipitation and temperature data. The graph shows that the yearly average temperature of this area is 19.2° C and annual precipitation is 297mm. From January to April, the temperature was more than 20 °C, but after that, it significantly dropped and reached nearly 10° C. The graph illustrates that the summer starts from September to March and the winter is from April to August. In the winter, less precipitation happens, but from January to March, precipitation is high rather than in other months.

7. Identify Changes on a Monthly Basis Atmospheric Conditions

7.1 Compare Precipitation and Evaporation:

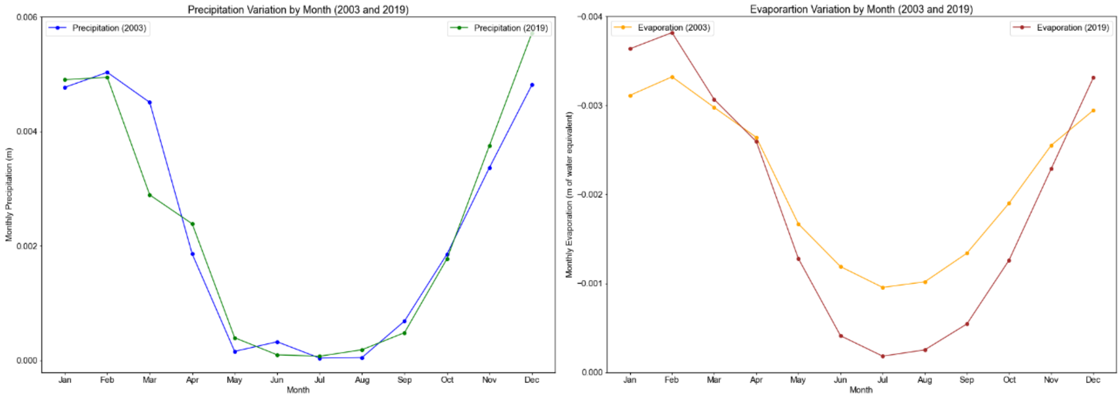

Figure 5: Monthly Precipitation and Evaporation Between 2003 and 2019

Between 2003 and 2019, the yearly precipitation did not change significantly(Figure 5). The graph indicates that the most rain fell from January to March, then decreased dramatically and riched in 0.0m from May to August. It climbed rapidly from September to December. However, evaporation had varied somewhat between these two years. Monthly evaporation between May and September in 2003 was roughly -0.002m, whilst evaporation in 2019 is less than -0.001m. It's possible that this is due to the fact that there is less precipitation during those months.

7.2 Compare Average Temperature and Soil Temperature:

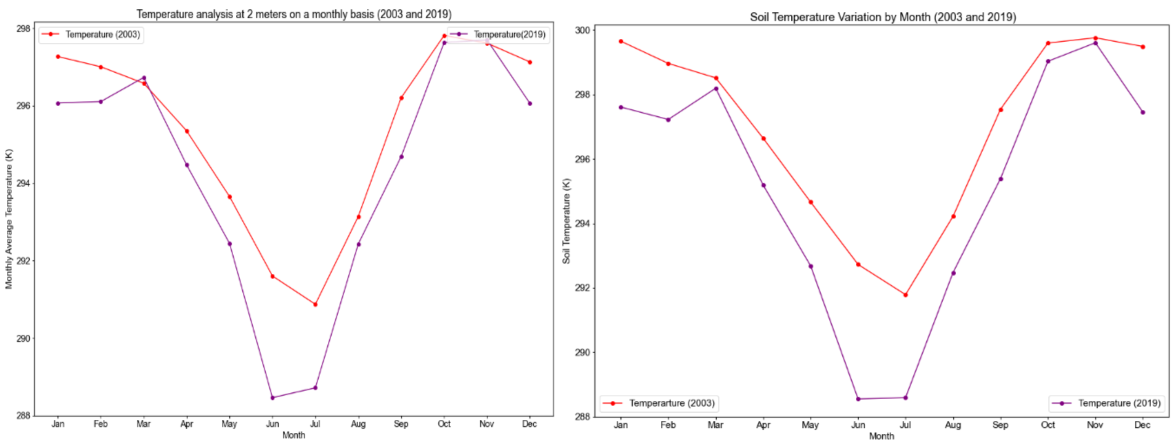

Figure 6: Monthly Temperature and Soil Temperature Between 2003 and 2019

Every month, we monitor the temperature at 2 metres and record it in Kelvin for this study. A similar line graph emerges when we compare the monthly average temperature and soil temperature in that location. In 2019, there is a significant temperature difference between June and July. When we compare that to 2003, we can see that the average temperature is almost 290K. In 2019, however, it was below 280K. Because we know that when the temperature rises, the soil temperature rises with it, this two-line graph indicates that in October and November, the temperature and soil temperature are both over 298K.

7.3 Compare Latent Heat Flux and Sensible Heat Flux:

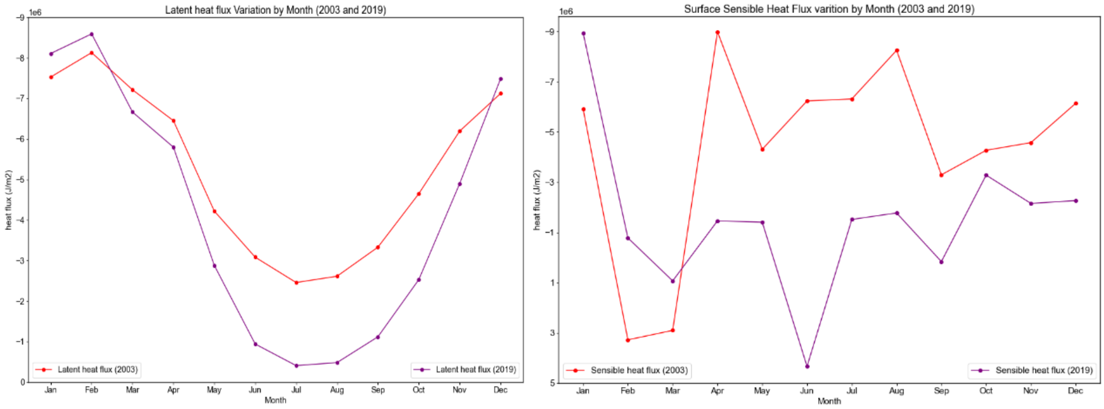

Figure 7: Latent Heat Flux and Sensible Heat Flux Between 2003 and 2019

If we compare latent heat flux between these two years, we can see that in January and February, they are in the similar above -7 J/m^2 and then they reduced significantly. Comparing these two years, 2019 shows dramatic changes between June and August. In the right corner, we see the sensible heat flux. Between 2003 and 2019, sensible heat flux shows a sharp increase and decrease. Consider 2003 sensible heat flux; it jumps 3 J/m^2 to -9 J/m^2(from March to April), whereas in 2019, it comes down from -9 J/m^2 to 5 J/m^2(from January to June). But overall, we can say that comparing these two years of sensible heat flux show us similar changes.

7.4 Soil-Water Layer:

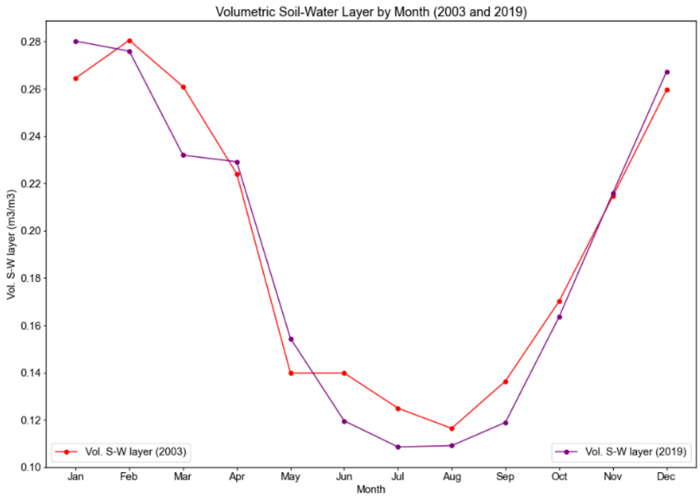

Figure 8: Soil - Water Layer Between 2003 and 2019

Similarities may be seen in the soil water layer from 2003 and 2019(Figure 8). It was over 0.26 m^3/m^3 in January for both years, then rapidly declined until August, where they both reached their lowest point (about 0.12 m^3/m^3). Precipitation began to fall in that area in September, and as a result, the soil water layer grew considerably, reaching 0.26 m^3/m^3 between November and December. It's possible that the soil water layer hasn't altered all that much throughout the years.

7.5 Compare Leaf Area Index and Photosynthetically Radiation:

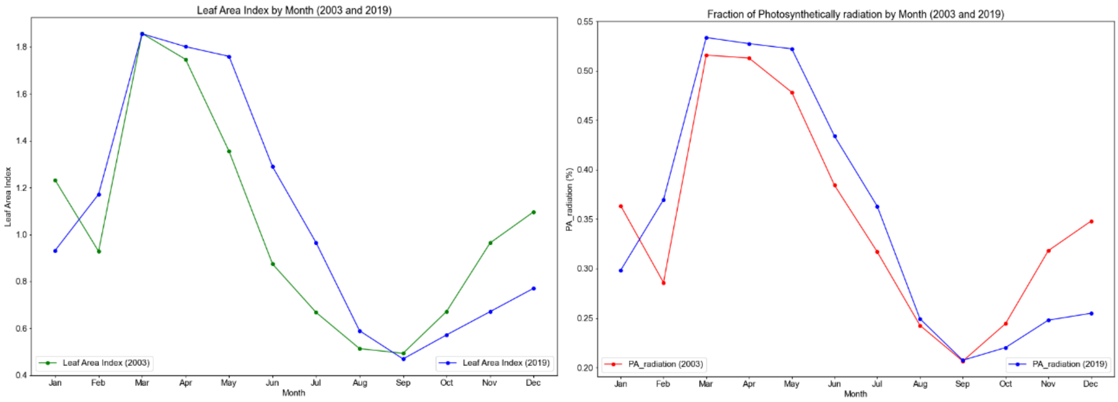

Figure 9: Leaf Area Index and Photosynthetically Radiation Between 2003 and 2019

For plants, the leaf area index is a critical structural characteristic. It's the most important source of energy and mass transfer. Evapotranspiration, photosynthesis, and canopy interception are all intimately connected. The leaf area index is shown on the left side of figure 9. When we compare the leaf area index from 2003 to 2019, we can see that 2019 has a lower rate, implying that the area of vegetation and agriculture land in that area has shrunk since 2003. The leaf area index decreased from 1.8 to 0.4 from March to September, and when compared to photosynthetically, it displays a similar pattern. It receives solar radiation from a photosynthetic organism and transfers the energy to the plant canopy through photosynthesis. The photosynthetic radiation is seen on the right side of figure 9. They are at the same point in September for both years (around 0.20 percent). And, since 2003 is higher than 2019, it's probable that the vegetative area has shrunk.

8. Conclusion

This paper aims to look at changes in surface fluxes in South African areas between 2003 and 2019. We also conducted an analysis of two-period variations in atmospheric conditions.

9. References

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