Climate over Northern Africa: Change, Variability and the Impact of the Nile River on Egypt

Introduction

Currently, the effects of climate change are already felt by people across Africa. Change in temperature has affected the health, livelihoods, food productivity, water availability, and overall security of the African people. Observable effects of climate change on water resources in Africa include: flooding, drought, change in distribution of rainfall, drying-up of rivers, melting of glaciers and the receding of bodies of water. Droughts, heat stress and flooding have led to a reduction in crop yields and livestock productivity. Severe flooding and intense droughts have led to the destruction of many homes, shelters and villages across Africa. Conflicts over resources also exacerbate these impacts and, in turn, contribute to the ongoing migration within and between countries in Africa. The hypothesis posed is that *climate has changed over northern Africa in the last 60 years: temperature has increased and rainfall has decreased over sensitive regions such as upstream the Nile River, and natural climate variability has some role on these trends.* This study has the following objectives: 1) identify what the normal climate is, 2) determine and assess if there is any change in the normal climate, and 3) clarify the relative role of known large-scale phenomena over the region of northern Africa. With knowledge of the normal climate, a change and variability of this normal climate can be established, leading into the impacts of global phenomena had over this change and variability. With this knowledge, not only will we be able to take steps to limiting the increase of global climate change, but saving our planet.

Methods

A Macintosh machine linked to a Linux-based cluster for general use by all users in the Atmospheric and Oceanic Science Department was used for this study. The cluster includes 32 computers, 256 GB of memory and 4TB of storage. The open access software named GrADS. This software is used to make calculations and display the processed information. An HP color printer, model: Laserjet 4700, was used for printing of figures for the use of further analyzation.

Characterization of the mean or "normal " climate. For this, the long-term means or climatology were calculated for the period 1950-2013.

↓

Identification of the correlations between river discharge at the Dongola station (30.48°E, 19.18°N) and precipitation amounts in the surrounding region.

↓

Identification of the regions with the largest year-to-year (i.e. interannual variability via standard deviations.

↓

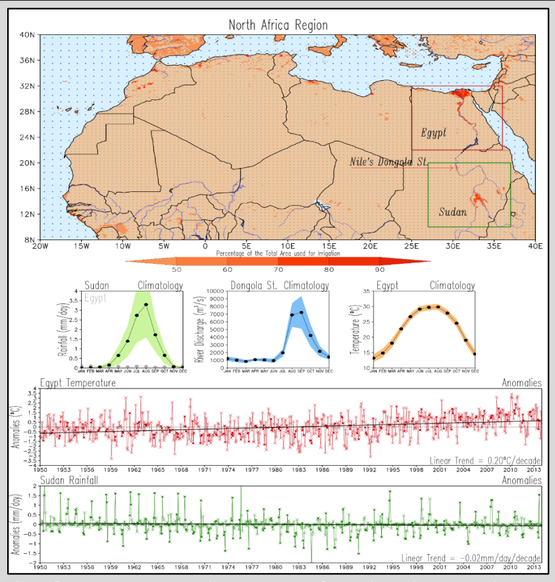
Identification of changes in the mean climate and long-term linear trends via the least squares method.

↓

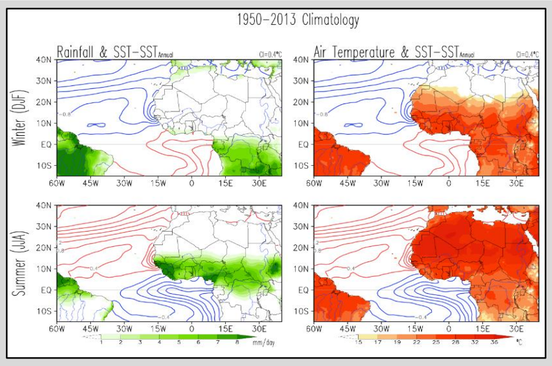
Identification of the impact that global scale phenomena, such as AMO, ENSO and the Atlantic Nino have over the climate of the region was explored via the least-squared method.

Internship site; Building 224 Computer and Space Sciences Building at the University of Maryland, College Park

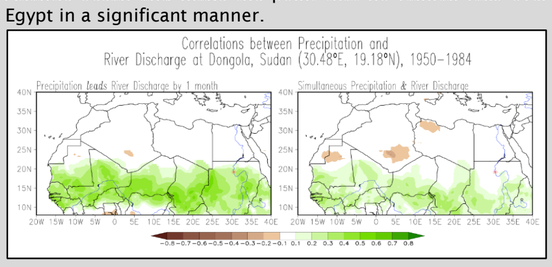
Findings



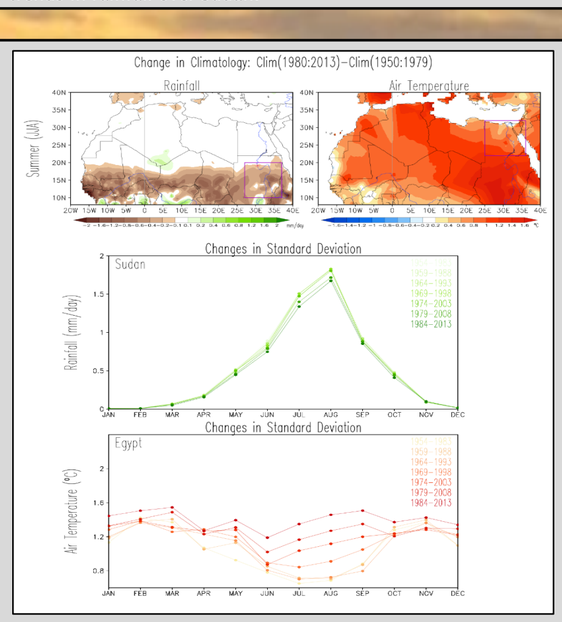
This figure presents the region of study, showing the grid points where data is extracted from climate stations and introduces the particularities of a focus region of study: Egypt. Egypt is largely dependent on irrigation from the Nile, which in turn will depend on precipitation upstream over Sudan. Data indicates that during the summer, the river has the largest water flow and more rainfall falls upstream. Rainfall increases from July to August, and river flow increases one month later from August to September. Temperature over Egypt and rainfall over Sudan change year-to-year reflecting not only the impact of large-scale global phenomena but also presents increasing trends in temperatures over Egypt and decreasing trends in rainfall over Sudan.



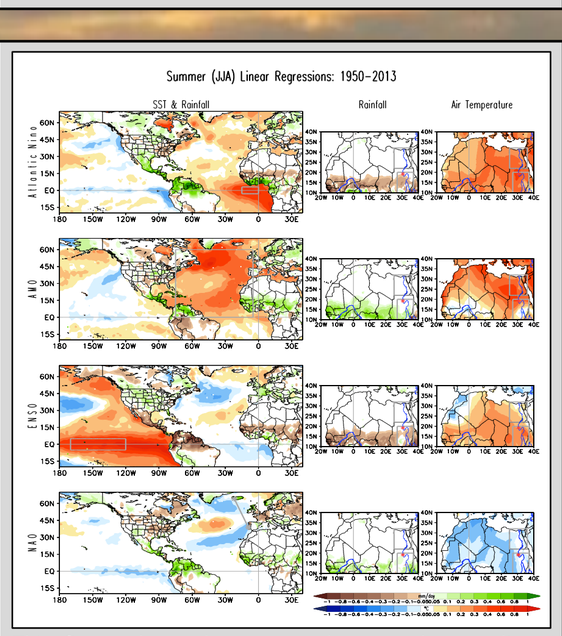
This figure makes the point of the climatological features of the region. Precipitation upstream the Nile, and temperature over Egypt follow the rhythm of the warming waters over the Atlantic ocean and make the point that no rainfall falls over Egypt in a significant manner.



This figure makes the connection between Nile River discharge and upstream rainfall. This connection is not instantaneous due to a lag of one month: when rain occurs over Sudan and other regions along the same latitudinal band, the river level rises one month later at the station of Dongola.



These figures show that climate has been changing over the past 63 years in the region. Particularly during the summer, the mean climate (differences in climatologies) shows that there is less rainfall and increased temperatures as well as in its interannual (year-to-year) variability. In summation, climate is changing but human activities cannot be the specific causal agent.



This figure shows that among the more known climate phenomena associated to the natural variability of the climate system, some have an impact on summer rainfall and temperatures impacting Egypt. El Nino Southern Oscillation and Atlantic Nino have the most impact on precipitation while Atlantic Multi-decadal Oscillation has the most impact on air temperature.

Conclusion

Based on the data, the hypothesis posed prior to experimentation that stated that *climate has changed over northern Africa in the last 60 years: temperature has increased and rainfall has decreased over sensitive regions such as upstream the Nile River, and natural climate variability has some role on these trends*, holds true. This project is a study of climate variability and change in a region of Africa that is not highly explored and researched but very sensitive to climatic phenomena. There are opportunities to use the findings of this particular study and apply them to the real world, such as, through agricultural practices and environmental conservation. Another region in the world could be researched through the same processes utilized by this particular study.

Acknowledgements

I would like to thank my mentor, Dr. Alfredo Ruiz-Barradas, and the Department of Atmospheric and Oceanic Science at UMD, Mrs. Alexis Donoghue, Mrs. Jane Hemelt and a special thanks to my parents, Mr. Ahmed Tayel and Mrs. Naglaa Tayel for their support and motivation.

Salma Tayel