Meteorological Developments of Dust Events in Senegal

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Introduction

Every year dust storms in the Sahara Desert bring copious amounts of dust into Senegal, exposing a population of over 16 million to unhealthy levels PM_{10} (Senegal, 2019). Senegal is located on the western coast of Africa, with 14 administrative districts. The capital of Senegal, Dakar, is home to over 3 million people in the city and the surrounding metropolitan area (Senegal, 2019). Due to Senegal's location southwest of the Sahara, the country is subjected to dust at a high frequency. Statistics from NASA have found that over 180 million tons of dust are picked up in the Sahara every year (Carlocwiz). These storms pick up dust from active dust regions, as well as local dust in Senegal, and bring hazardous levels of dust into the country for multiple days. Exposure from dust at this frequency has been associated with health impacts to the respiratory and cardiovascular systems (World Health, 2006). There are limited warnings established for dust storms in Senegal, with only a small population of the country having access to the government alerts. Synoptic scale features can drive the storms, with both high and low pressure systems having caused severe dust events. In December 2017, a ten day dust event in Senegal was driven by a high pressure system, whereas a ten day storm of similar severity in March 2019 was driven by a low pressure system.

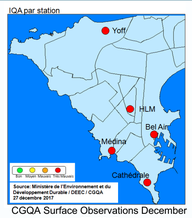
The objectives of this project are:

- Identify two ten day dust events: December 19-29, 2017 and March 5-15, 2019
- Evaluate models to assess how the entire country was impacted by both storms
- Determine the meteorological driving forces behind each storm

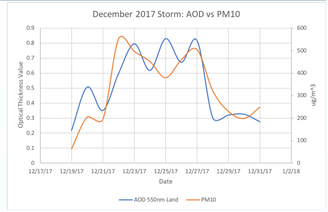
Methodology

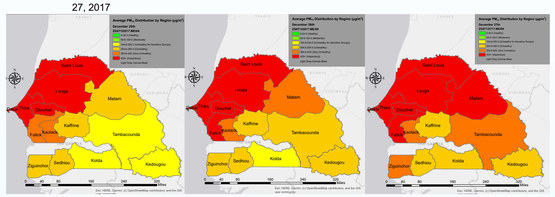
- NASA's Giovanni database was used to produce Aerosol Optical Depth (AOD) from MODIS-Terra. Area averaged of 550nm AOD data was produced for the ten day periods of both storms
- Surface observations taken by the Centre de Gestin de la Qualtié de l'Air (CGQA) in Dakar, Senegal, were used to compare the modeled data with what was actually recorded during the length of the storms. CGQA assesses the quality of the air and measures PM_{10} values, although there is data missing
- NCEP reanalysis using NOAA's ESRL daily mean composites was used to create sea level pressure maps to assess the synoptic scale features driving each storm
- The WRF-Chem model is a regional model which analyzes the distribution and path of dust, and measures the amount of PM_{10} in the atmosphere. The data calculated by WRF was inputted into a GIS framework to develop imagery for the severity of PM_{10} for each day of the storms across the 14 districts and was categorized by the US Air Quality Index

Data 2017

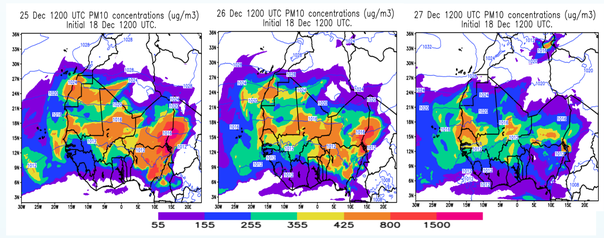


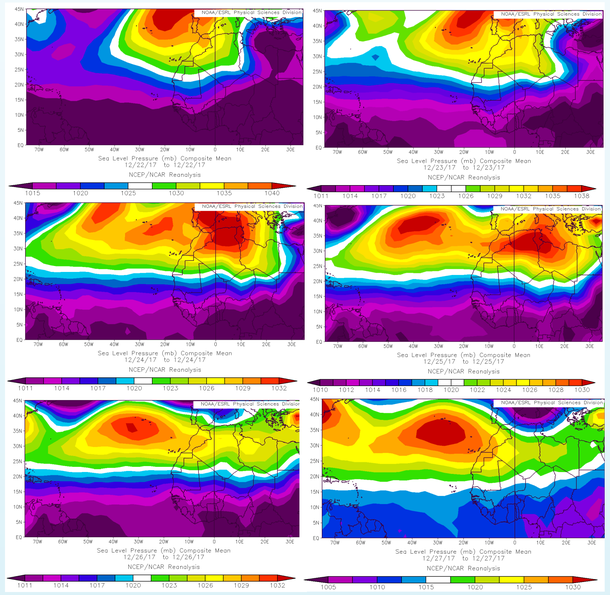
CGQA Surface Observations December 27, 2017



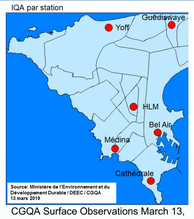


Daily PM_{10} WRF Model values averaged for Senegal's 14 administrative districts: December 25-27, 2017

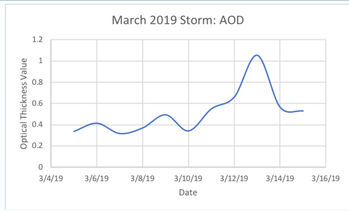


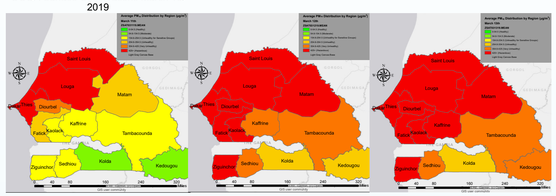


Data 2019

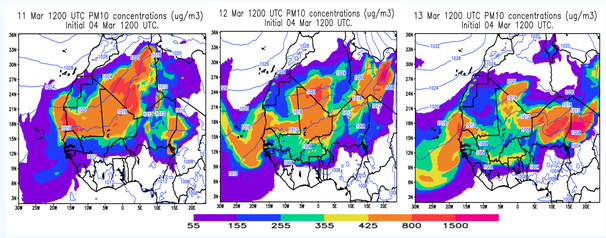


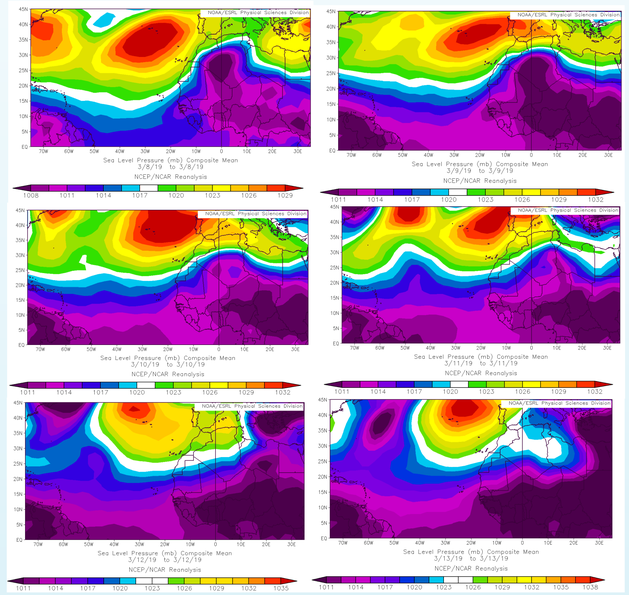
CGQA Surface Observations March 13, 2019





Daily PM_{10} WRF Model values averaged for Senegal's 14 administrative districts: March 11-13 , 2019





Results 2017

- For the 2017 storm, the AOD data, averaged over all of Senegal, closely matches the CGQA surface recorded levels from Dakar
- Although there are no PM_{10} values for 2019, the surface observations in Dakar from March 13 align with the highest AOD values from the storm
- The levels of PM_{10} from the WRF model data for Senegal's 14 administrative districts coincides with the AOD and observation data for both 2017 and 2019
- The regional WRF model for both storms displays the large-scale distribution and impact of dust the events had across Northwest Africa
- **2017 Meteorology**: The event formed due to a Southerly Azores high, picking up dust and funneling between the high and low pressure systems
- **2019 Meteorology**: The event formed due to a strong low pressure system developing over Algeria, causing dust to be picked up and carried through the trough

Conclusion

- The December 2017 event brought 7 or more days of unhealthy PM_{10} levels to over 12million people, 86% of the county's population
- The March 2019 event brought unhealthy PM_{10} levels for 7 or more days to 10million, 76% of the population
- Unhealthy PM_{10} is between 255-354.5 $\mu g/m^3$
- According to the World Health Organization (WHO), the safe guideline for 24-hour PM_{10} is $50\mu g/m^3$ (World Health, 2006)
- Long term exposure to unhealthy levels of PM has shown to increase lung cancer and cardiopulmonary mortality (Pascal, 2013)
- The WHO recommends immediate action for countries not meeting the safe daily PM averages
- What this means for Senegal: PM monitoring, warnings, and informative systems should be established throughout the country

References

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