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# A Trend Analysis of Aerosol Related Parameters and their Relation to Precipitation Variability in Arizona


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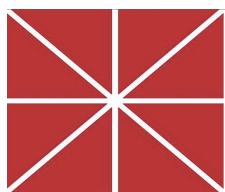
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# A Trend Analysis of Aerosol Related Parameters and their Relation to Precipitation Variability in Arizona

Chapman University

Rasmussen, Krista and El-Askary, Hesham



## Introduction

Arizona's unique climate, terrain, and geographic location cause distinct weather patterns, particularly in the summer months with the formation of the North American Monsoon. The North American Monsoon that impacts Arizona forms when low level moisture is moved predominantly from the Gulf of California and eastern Pacific Ocean to the southwestern United States. The North American Monsoon is unique from typical precipitation because it is extremely variable and is characterized by short, intense rainfall paired with extreme thunderstorms. These strong, sudden thunderstorms lead to the formation of Haboobs, or large dust storms. They form when the front of a travelling thunderstorm cell pushes air down and forward, picking up dust and debris from the ground as it picks up speed. Wind in these storms can reach up to 60 MPH, causing sand and debris walls as high as 10,000 feet to move over the desert for an average period of time between ten to thirty minutes. It has been proven that desert dust is found to be one of the major sources of aerosols over the world affecting the regional climate and precipitation patterns. The vertical mix-up of dust with other emissions impact the radiation budget and precipitation. The objective of our research is to investigate if there is a correlation between haboob outbreaks, resulting in large dust storms over Arizona, and the precipitation patterns over the region.

Figure 1. Monsoon in Arizona.



## Hypothesis:

We believe that haboobs may increase precipitation in Arizona because the dust particles absorb moisture from the air, causing larger storms to occur when these swollen particles of dust mix with the rain of the monsoons. The expected outcome would be for a certain degree of dependency and correlation to exist between AOD, Angstrom Exponent, and precipitation.

## Experimental Method

- An extensive literature review was prepared on remote sensing and previous research performed regarding haboobs and dust and precipitation dynamics.
- Data from MODIS, TRMM, and the GOCART model was collected from NASA's Giovanni database.
- Monthly data was collected from the years 2002 to 2012 for five locations in AZ using many different parameters, such as aerosol optical depth at 550 nm, Angstrom Exponent, and Precipitation.
- Angstrom Exponent, AOD, and the Precipitation data was decomposed to show trends, and cross correlated to indicate degrees of dependency.



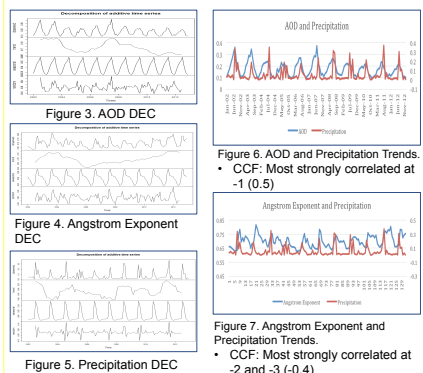
Figure 2. Five observed locations in Arizona.

## Results

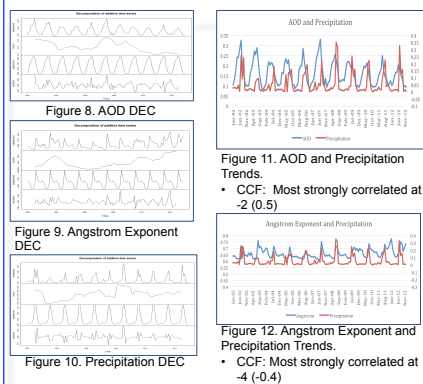
There is a distinctive seasonal component influencing the AOD, Angstrom, and Precipitation data. The North American Monsoon causes the majority of precipitation to occur during the summer months, which also causes the Angstrom Exponent and AOD to change dramatically. Aerosol Optical Depth increases, while Angstrom exponent decreases during the summer because the atmosphere is less transparent due to the large amount of dust that is pushed high up into the atmosphere from the haboobs. AOD and Precipitation tend to be positively correlated, with a lag ranging from 0 to -7 months, with an average lag of -3.4 months. Precipitation and AOD tend to have correlations around 0.3 and 0.4. Precipitation and AOD tend to have the weakest correlations and were occasionally below the 95% confidence level and thus not correlated. Angstrom Exponent and Precipitation tend to be negatively correlated, with values around 0.3. The lag ranges from -2 to -7 months, with an average lag of -2.2 months. This means that there is an average lag of about 2 months for the trend of precipitation to match up with the trend of Angstrom Exponent. As Angstrom

Exponent increases due to more dust, residual dust in the atmosphere could be influencing precipitation patterns for months after haboobs actually occur. The strongest correlations tended to have between 0 and 2 months lag, which indicates that dust likely remains in the atmosphere in influential levels for about 2 months after haboobs. Angstrom and AOD tend to have the strongest correlations, with values around -0.5 and -0.6. Angstrom Exponent and AOD values indicated a lag of -2 to 2 months, with an average lag of 0 months. This is to be expected because AOD and Angstrom Exponent immediately impact one another. Locations 3 and 4 tended to have weaker correlation values than other locations for all parameters. This can be attributed to the complexity of the terrain in locations 3 and 4. Location 3 includes the Grand Canyon, which can create weather systems of it's own due to drastic changes in elevation. Location 4 is east of the Grand Canyon, which is predominantly composed of extremely high desert plains.

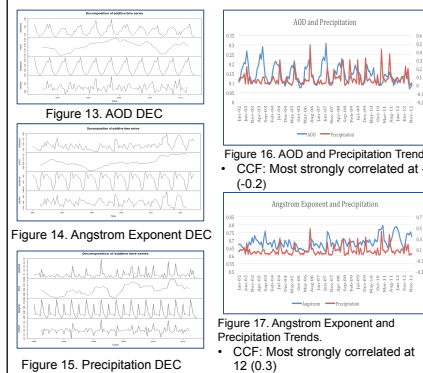
### Location 1



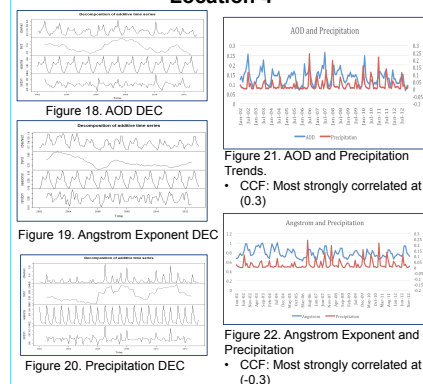
### Location 2



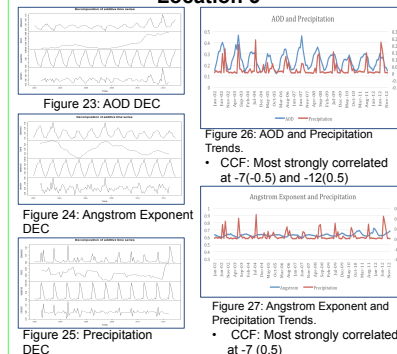
### Location 3



### Location 4



### Location 5



## Conclusion

- We found that while AOD, Angstrom Exponent, and precipitation patterns are dependent on location, a certain degree of dependency does exist between them owed to aerosols microphysics.
- Each of the five locations in Arizona indicated that:
  - Precipitation increases as AOD increases and vice versa.
  - Angstrom Exponent decreases as precipitation increases, which indicates that the desert dust does have a substantial impact on rainfall.
  - AOD and Angstrom are correlated on an immediate time-scale.

Considering these conclusions it can be assumed that at a micro-physical level there are complex interactions occurring between the desert dust and water vapor. While the dust appears to be a factor in increasing precipitation, it is only one of many interactions that impacts the amount of precipitation on a greater scale in Arizona.

## Future Research

- Future research that could be performed would include:
- Analyzing data using different parameters in the models.
  - Studying the health impacts of haboobs. (ie. respiratory conditions, allergies, airborne diseases)
  - Studying the influence of natural flooding from heavy rainfall on Sonoran desert ecosystems.
  - Study the impact of haboobs on city infrastructures in order to help arid locations, with large dust storms prepare better for haboobs.

## Acknowledgments

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## References

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- Rumore, Kori. (2012) Tucson monsoon: Why does it begin Friday? *AZ Daily Star*.