Site-Based Observations of a Saharan Dust Storm's Impacts on Evapotranspiration in North-Central Florida

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Introduction

21 June – 4 July 2020 Dust Storm Event

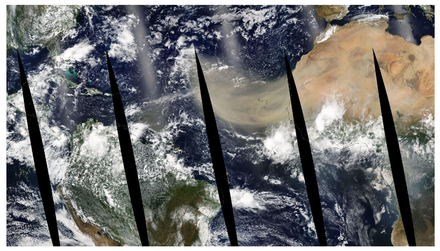


Image from NASA Worldview
19 June 2020
Aqua / MODIS
Corrected Reflectance

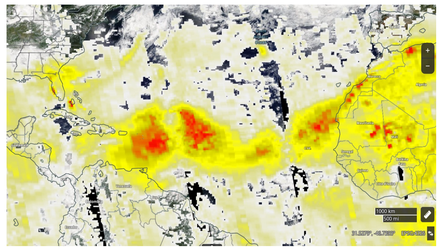


Image from NASA Worldview
26 June 2020
Suomi NPP / OMPS
Aerosol Index

Why Is Researching Dust Storms Important?

Saharan dust storms serve an important role in the western Atlantic's climate in their contribution to Earth's radiation budget, modulating sea surface temperatures (SSTs), fertilizing ecosystems, and suppressing cloud and precipitation patterns (Yuan et al., 2020).

Saharan dust storms are expected to become less frequent in this region as SSTs continue to rise (Yuan et al., 2020). Predicting the climate response to this change requires a keen understanding of how the presence of these storms affect evapotranspiration (ET) and its indicators.

What is Evapotranspiration and Why Is It Important?

Evapotranspiration (ET) refers to the evaporation of water from Earth's surface and plants. When ET occurs, energy is released into the environment in the form of latent heat, or the energy associated with the phase change of water. Latent heat is different from sensible heat because it does not warm the air temperature, so when latent heat is released into the environment, less energy is directed towards warming. Therefore, ET helps to moderate temperatures which can have a significant impact on weather and climate.

Factors that control ET include net radiation at the surface, air temperature, relative humidity, wind speed, and water availability. For simplicity, this study will focus on observations of net radiation, air temperature, and vapor pressure deficit (related to humidity) as indicators of ET.

Hypothesis

For ET to occur, enough energy must be absorbed by water molecules. The primary source of this energy is the sun, which emits energy most abundantly in the shortwave (high-energy) spectrum (most commonly in the range of visible light).

Saharan dust aerosols are thought to be efficient scatters of light, meaning less energy will reach the surface or does so less directly. This should cause ET to decrease.

Variables		Hypothesis
Indicators of ET	Net Radiation	↓
	Air Temperature	↓
	Vapor Pressure Deficit (related to humidity)	↓
Evapotranspiration (ET)		↓

Data and Methods

Data Sources

- Moderate Resolution Imaging Spectrometer (MODIS) on Terra and Aqua satellites.
- NASA Aerosol Robotic Network (AERONET)
- NEON Flux Tower
- NASA's Global Land Data Assimilation System (GLDAS)
- ASOS reports from Iowa State University's Iowa Environmental Mesonet (IEM)

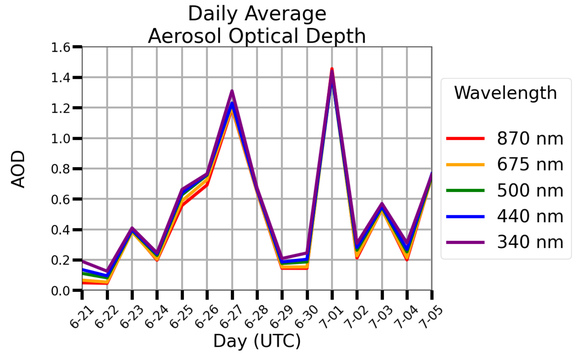
Methods

This study focused on observations from a single site. The ideal site for this study includes the presence of heavy dust aerosol concentrations but lacks interference from other factors such as cloud cover. This proved to be the NEON Ordway-Swisher Biological Station (NEON OSBS) located just east of Gainesville, FL. This site possessed a NEON flux tower with data available from the AmeriFlux Fluxnet, which reports readings of net radiation, air temperature, and vapor pressure deficit. This site also has a co-located NASA AERONET station, which helped to verify the presence of dust using aerosol optical depth (AOD) readings. Reanalysis data from the GLDAS was also used to verify if the model could capture the effects on ET by increased atmospheric aerosols.

Daily-averaged data of each indicator of ET and AOD was used. To analyze this data, the programming language Python was utilized to create a conceptual model to identify trends.

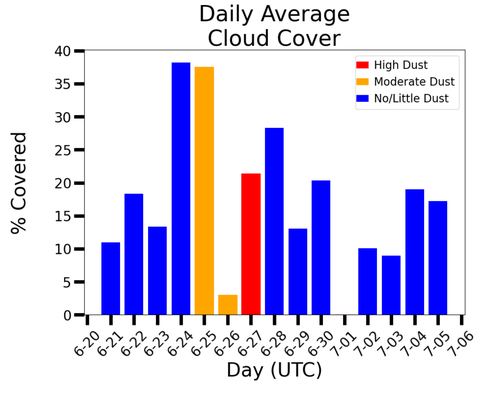
Results

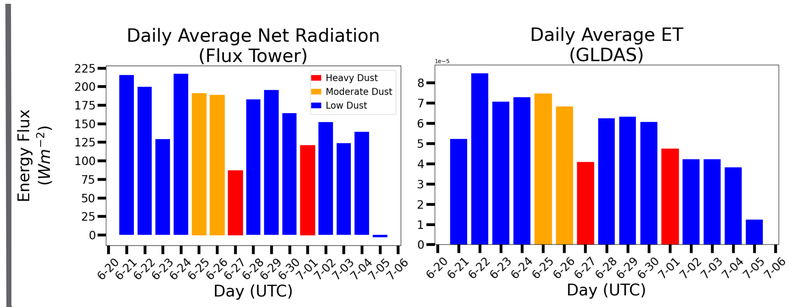
The heaviest dust concentrations at NEON OSBS were associated with 26 June and 1 July 2020.

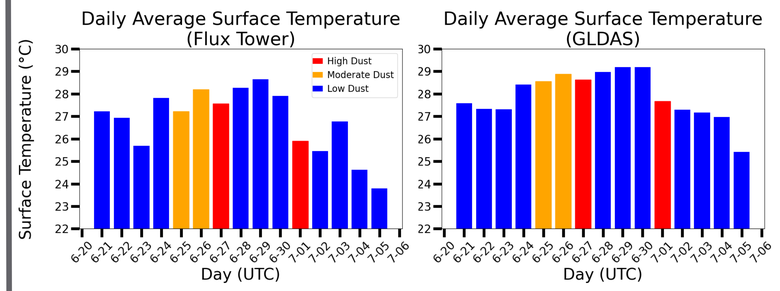


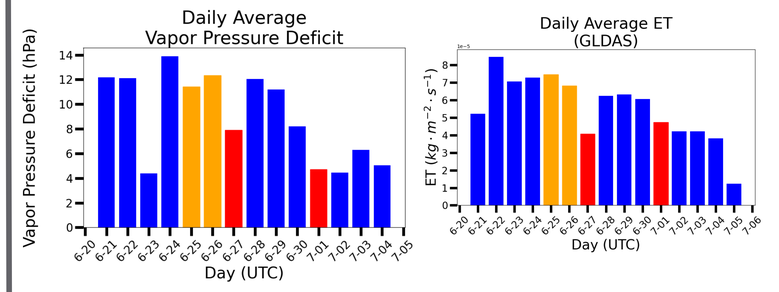
The daily average cloud cover never exceeded 40% and was relatively low during the days of interests. Therefore, any significant changes in indicators of ET would likely be be result of Saharan dust aerosols.

ASOS station ID: KGVN (Gainesville, FL)









Discussion and Conclusions

The days where dust concentrations were the heaviest saw noticeable decreases in all indicators of ET. The GLDAS prove to be a useful tool for estimating ET as it measurements were consistent with the findings from the flux tower. The results of this study supports the hypothesis that ET will decrease with increased Saharan dust concentrations.

Variables		Hypothesis	Flux Tower	GLDAS
Indicators of ET	Net Radiation	↓	↓	N/A
	Surface Temperature	↓	↓	↓
	Vapor Pressure Deficit	↓	↓	N/A
Evapotranspiration (ET)		↓	N/A	↓

Future Work

This study only showed one isolated event at one site over a short time frame, and daily averages are likely not a high enough resolution to capture changes in ET during this event. This study therefore cannot conclude correlations between each indicator of ET and AOD despite apparent trends. Further research is required to capture the full effect on ET by dust aerosols.