The impact of Canadian wildfire smoke on evapotranspiration in the Chesapeake Bay: Insights from NASA SARP

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INTRODUCTION & BACKGROUND

- Wildfires have an ever-growing presence around the world and have significant impacts on climate, agriculture, and health
- Large quantities of CO2, CO, and fine particulate matter are released into the atmosphere from wildfires as smoke
- This Wildfire smoke can reduce the amount of solar radiation that reaches the Earth's surface, which can affect evapotranspiration (ET)
- By studying the impact of wildfire smoke on solar radiation, ET, temperature, and humidity we can better understand the effects of wildfires on the environment

DATA & METHODS

- Initial Hypothesis: An increase in smoke leads to less radiative forcing and reduced ET rates in areas most affected by wildfire smoke
- Numerous datasets from William & Mary (W&M) and Rice Rivers Center (RRC) were utilized
- MODIS – Aerosol Optical Depth & Satellite Imaging
- Keck Lab Weather Station (W&M) – Modeled ET
- Flux Tower (RRC) – Observed ET
- Climate Variables: humidity, temperature, evapotranspiration, solar radiation, and aerosol optical depth
- Null data from the Flux Tower were linearly interpolated between to create a better visual representation of the data
- Data analysis was done using JupyterHub and Python
- Imaging and modeling was done using NASA Worldview

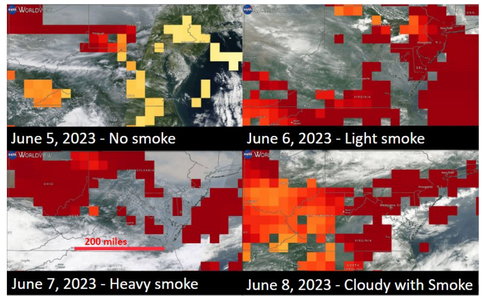

Figure 1. MODIS Aerosol Optical Depth as a proxy of smoke presence. Note that MODIS has challenges resolving signals in the presence of clouds

RRC as seen from the Dynamic Aviation B-200 research aircraft, the RRC flux tower, and field work!

DATA & CODE

Explore the data and code utilized in the analysis here!

RESULTS - Observed changes in Evapotranspiration associated with wildfire smoke in the Chesapeake Bay

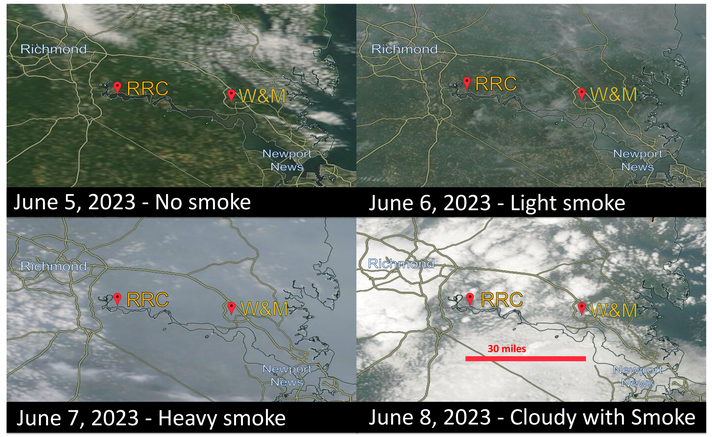

Figure 2. MODIS imagery showing when smoke rolls into the Chesapeake Bay region in summer 2023.

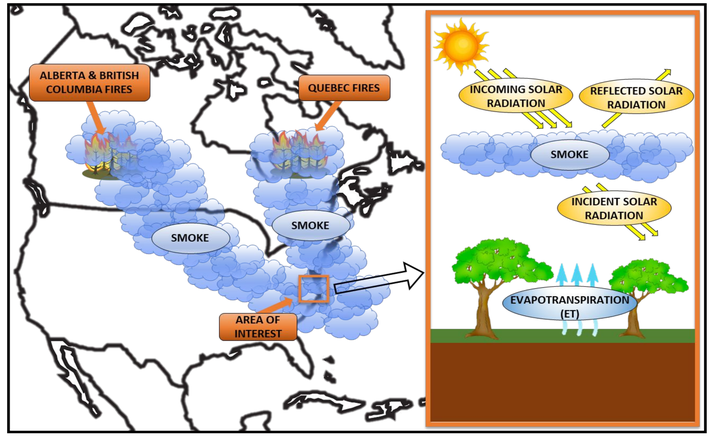

Figure 3. Canadian wildfire smoke drifting downwind to the Chesapeake Bay causing an increased in reflected solar radiation and decrease in incident solar radiation

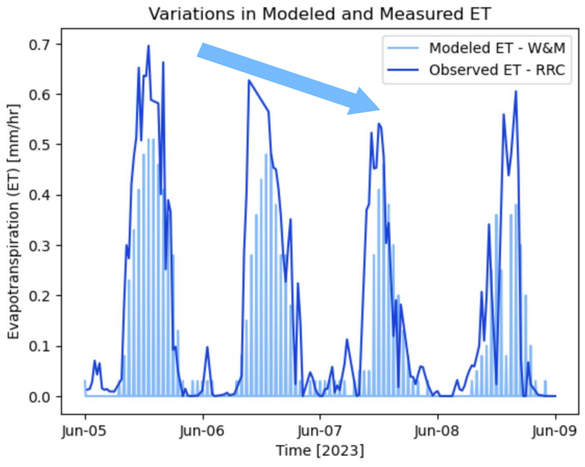

Figure 4. ET decreases during period of light and heavy smoke (June 6 & 7).

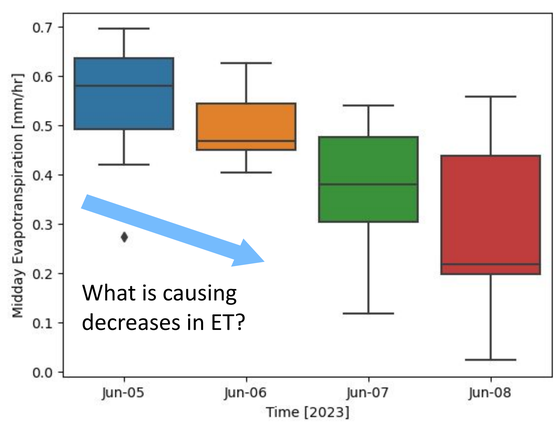

Figure 5. Boxplots of midday ET (9 AM to 3 PM) at the Rice Rivers Center. Note that ET is decreasing throughout the smoky period.

What is the likely cause of the decreasing ET during the smoky time period?

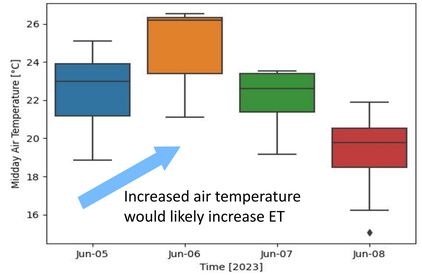

Figure 6. Boxplots of midday air temperature (9 AM to 3 PM).

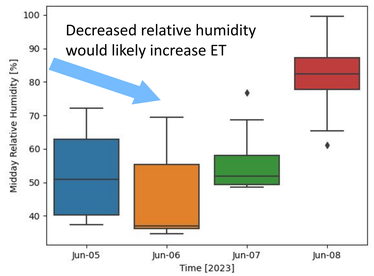

Figure 7. Boxplots of midday relative humidity (9 AM to 3 PM).

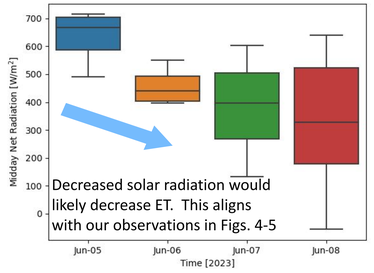

Figure 8. Boxplots of midday net radiation (9 AM to 3 PM).

FINDINGS & CONCLUSION

- Decreased solar radiation occurred with the presence of smoke and contributed to a linear decrease in ET values
- Modeled values were validated and the same trend was observed in the measured ET values from the flux tower
- As the relative humidity of the air increased, the rate of ET decreased
- Relative humidity and temperature were found to have an inverse relationship with the presence of smoke
- Although air temperature rose and humidity decreased, solar radiation had a more substantial impact on ET
- ET is complicated and has multiple affecting variables, with incoming solar radiation as a driving variable

FUTURE WORK

- Inspect NASA Pandora spectra data from smoke impacted and smoke free days during SARP
- Utilize SMAP and soil moisture data close to and far away from the fires to create a time series of soil moisture transects over the smoke-path
- Extend research towards how individual variables correlate with soil moisture
- Develop an API to seamlessly read in the desired data from the RRC Flux Tower
- Investigate variables at origin location of fire rather than localized region
- Incorporate future findings into irrigation schemes and managing water resources
- Track smoke plumes and investigate effects of air quality and particulate matter on human health
- Attribute CO2 increases to wildfire smoke plumes
- Other variables to study include wind speed, air pressure, vapor pressure deficit, and Photosynthetically Active Radiation

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References

- [1] EOSDIS Worldview. (n.d.). Worldview: Explore Your Dynamic Planet. Retrieved July 21, 2023, from https://worldview.earthdata.nasa.gov/
- [2] *KECK LAB Environmental Field Laboratory at the College of William and Mary*. Keckweather. (n.d.). https://media.wm.edu/content/as/kecklab/Weather/KeckWeather.htm
- [3] Flux tower data will be published to AmeriFlux