

Tracking Canadian Wildfires with GOES-R Products

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ABSTRACT

Canada's recent wildfires had severe consequences, including a drastic reduction in air quality due to smoke and particulate matter. These fires also caused significant environmental damage by releasing unprecedented amounts of air pollutants and greenhouse gases, contributing to climate change. Perhaps most concerning were the negative health impacts, with increased risks of injuries and respiratory problems. Our objective is to extract and analyze satellite data to track the evolution of smoke plumes and to better prepare for potential consequences of future wildfires. In this study we focus on the Canadian wildfires event in summer 2023.

What did we experience in summer 2023? On June 8th, the air became very foggy, and the sky was orange. Many came to school with masks on to avoid being affected by the heavily polluted air.



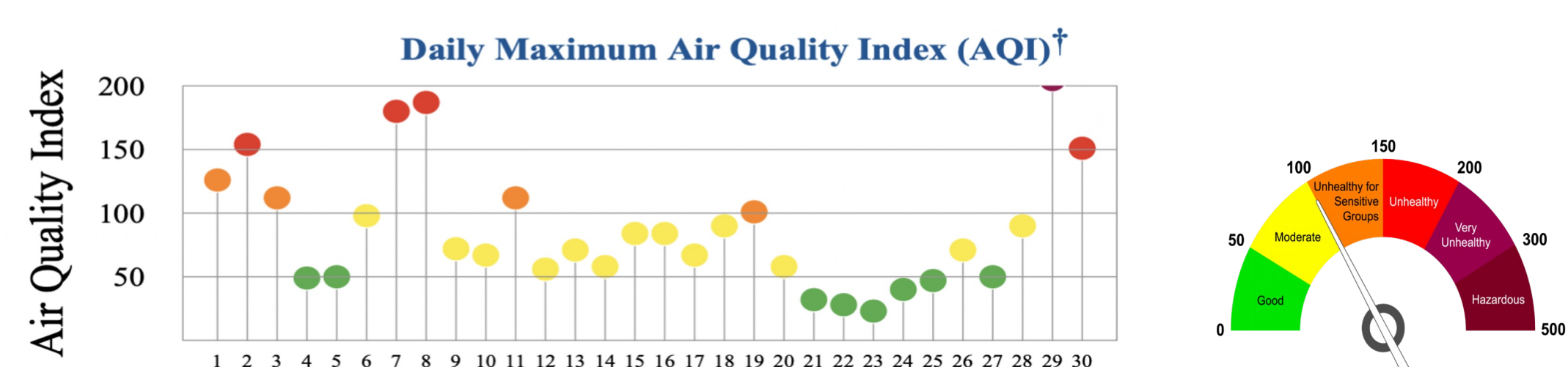
The picture on the right shows what the sky looked like in Baltimore on that day. It was extremely gloomy and polluted.

To track the smoke movement, we relied on the GOES-R satellite system. These geostationary satellites provide near real-time imagery and data covering the continental United States and parts of Canada. The key instrument onboard is the Advanced Baseline Imager (ABI), which captures high-resolution images of Earth across multiple spectral bands. This allows for highly accurate data and imagery used to observe various environmental aspects, including smoke plumes.

RESEARCH QUESTION

- June 8: "very unhealthy" air quality with the second highest historically recorded AQI in Baltimore area¹.
- June 29: Code "Red" all day with the highest recorded AQI¹.

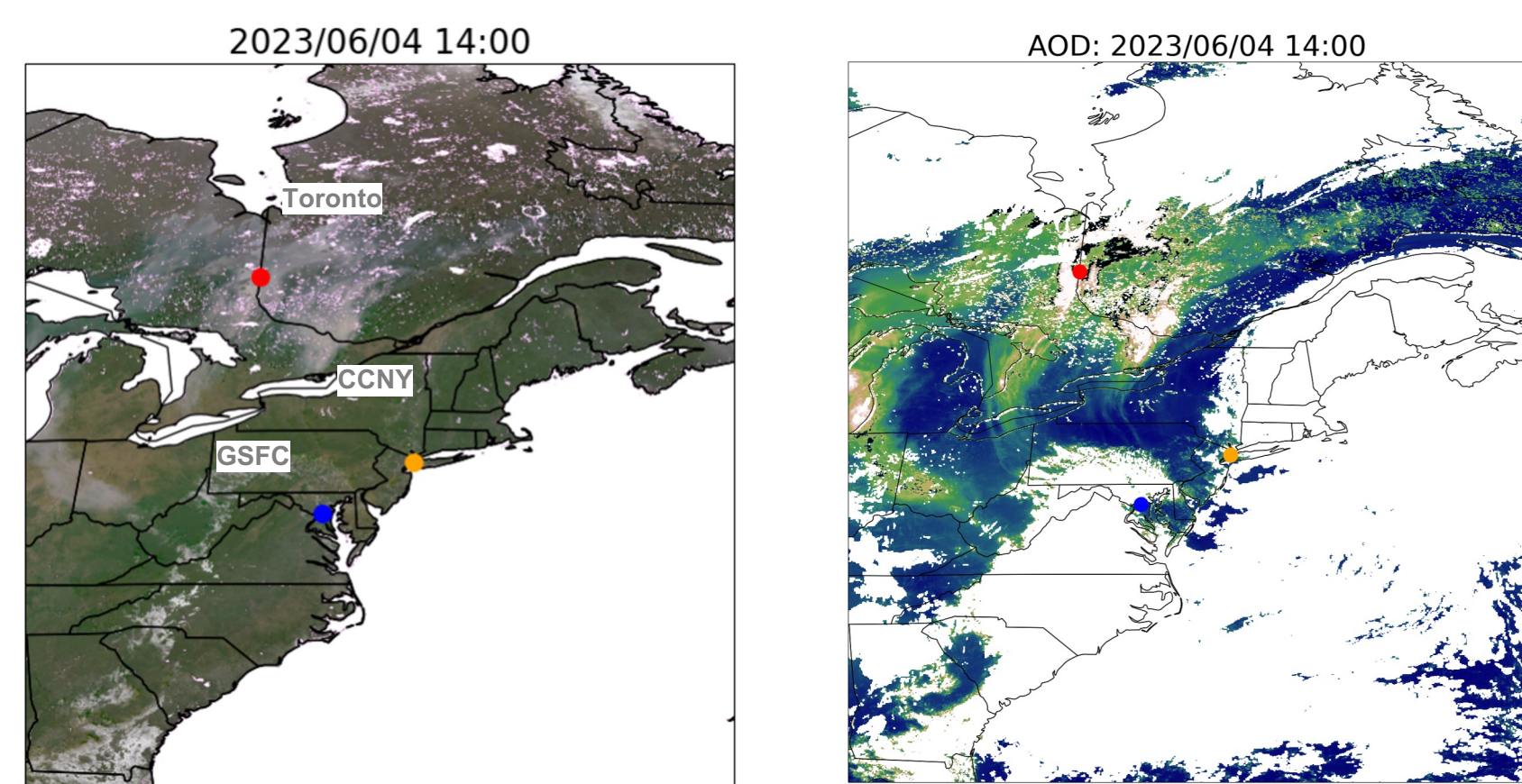
Quality of Air Baltimore, June 2023



Question: How can we use GOES-R ABI products to track the smoke from Canadian wildfires and to illustrate its impact on our local air quality?

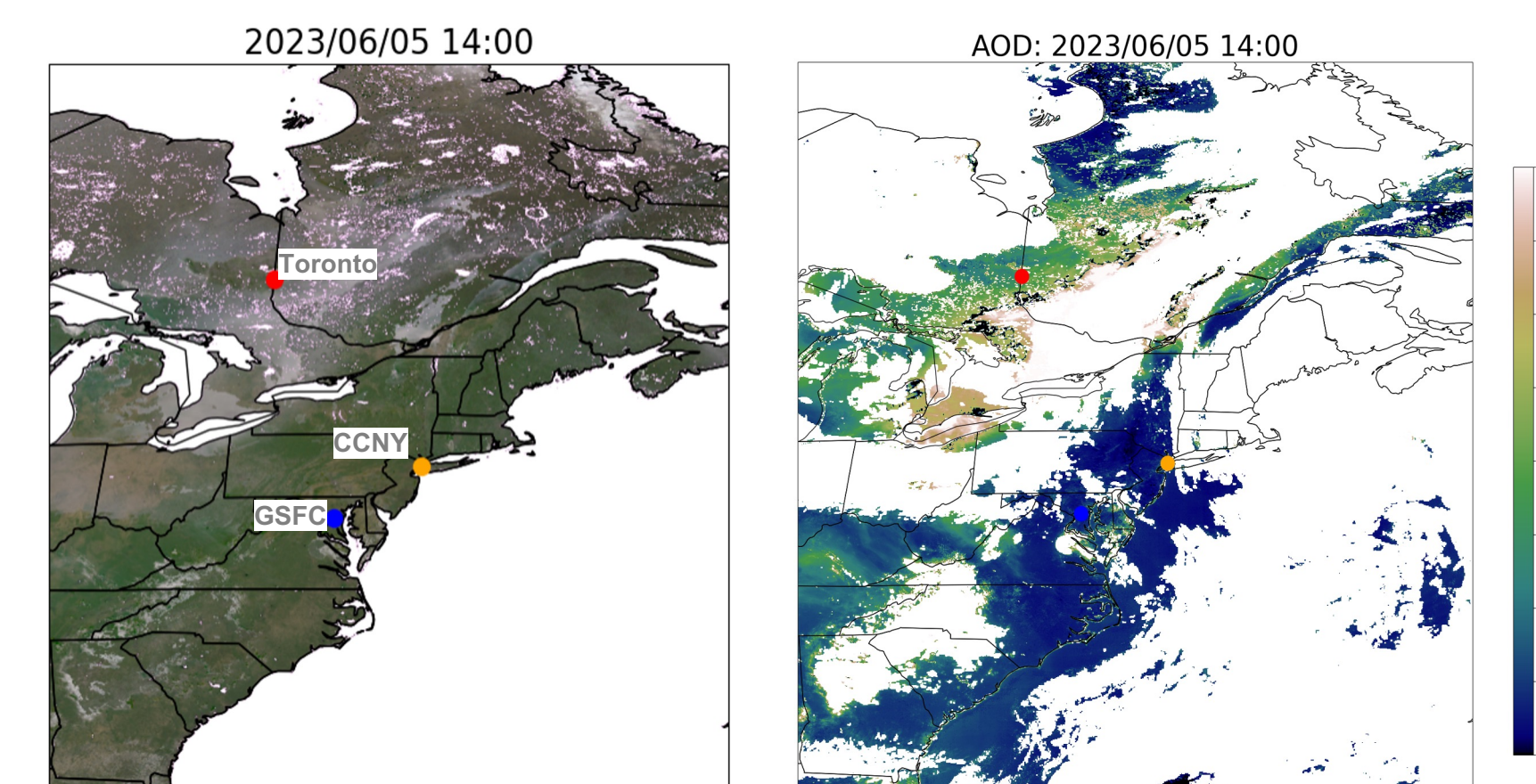
METHOD and GOES-R DATA

- **GOES-R Aerosol Optical Depth (AOD) Product²**
 - A measure of aerosols loading in the air; highly correlated with PM_{2.5} and Air Quality Index (AQI).
 - Retrieved using ABI bands 1, 2, 3, 5, and 6.
- **GOES-R Bidirectional Reflectance Factor (BRF)³**
 - To simulate the colors perceived by human eyes.
 - ABI bands 1, 2, and a linear combination of the top 3 were used as B, R, and G, respectively to create pseudo-RGB images.
- **Data Access:**
 - AWS <https://registry.opendata.aws/noaa-goes/> (Thanks NOAA and AWS for easy data access!)
- **Image generation:**
 - Images were generated using Python.



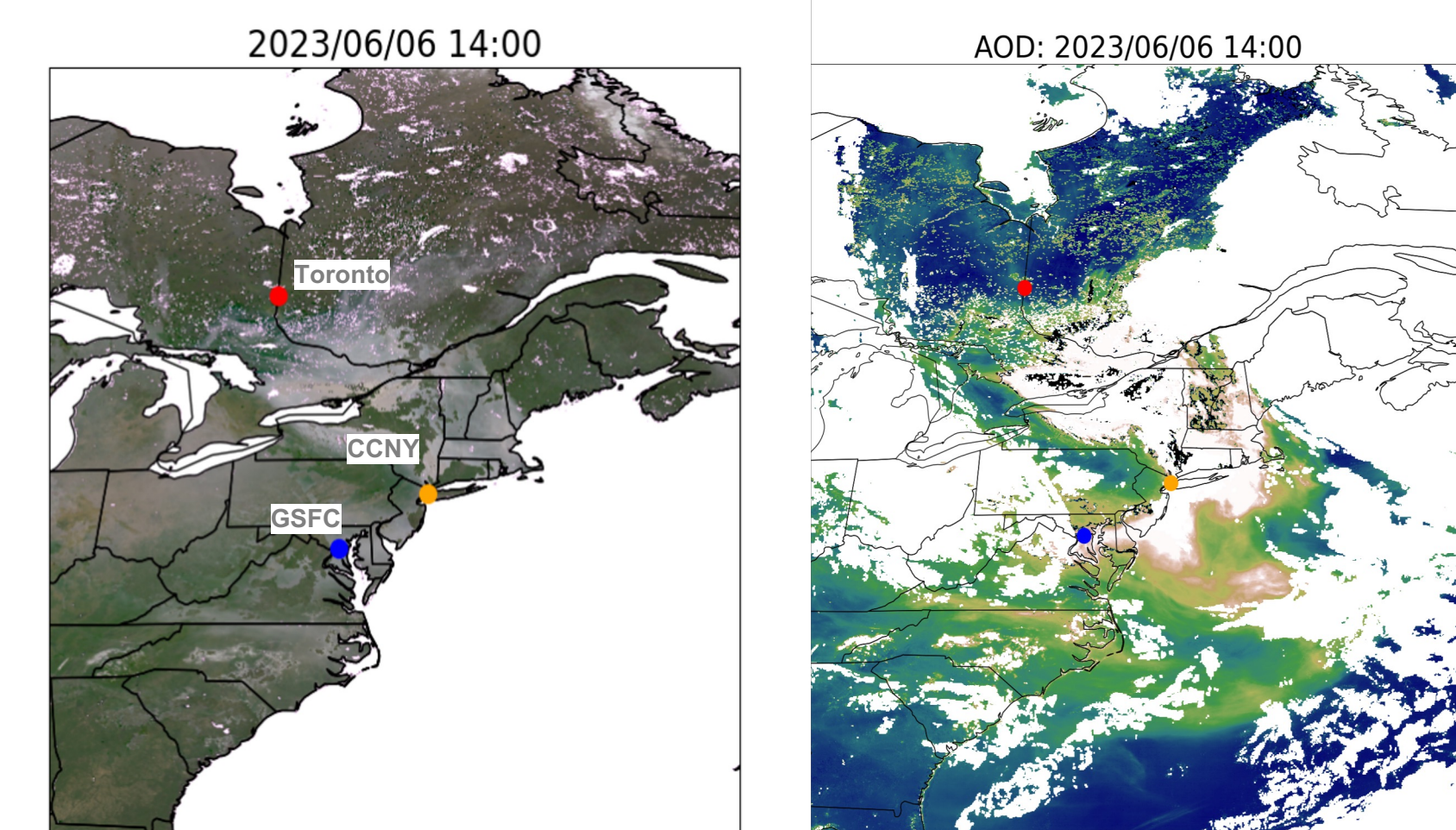
June 4th

- Smoke plume detected near Toronto, confirmed by high AOD (>0.5) and smoky appearance in RGB imagery.
- AOD readings in New York and Baltimore remain low (<0.25), indicating clear skies.



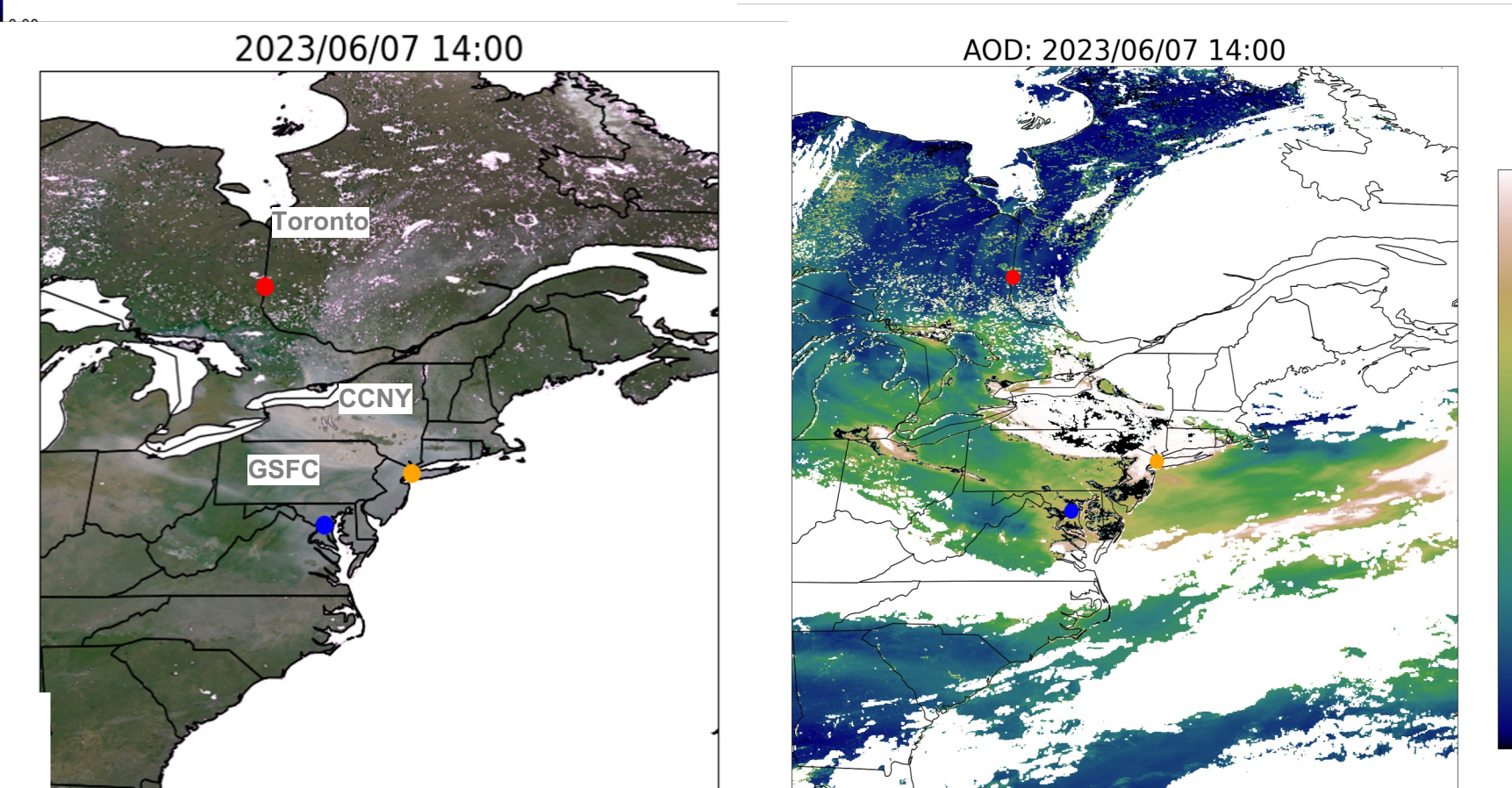
June 5th

- Smoke dispersion has increased, with AOD in Toronto remaining high (above 1).
- New York and Baltimore areas have clear skies with AOD below 0.25.



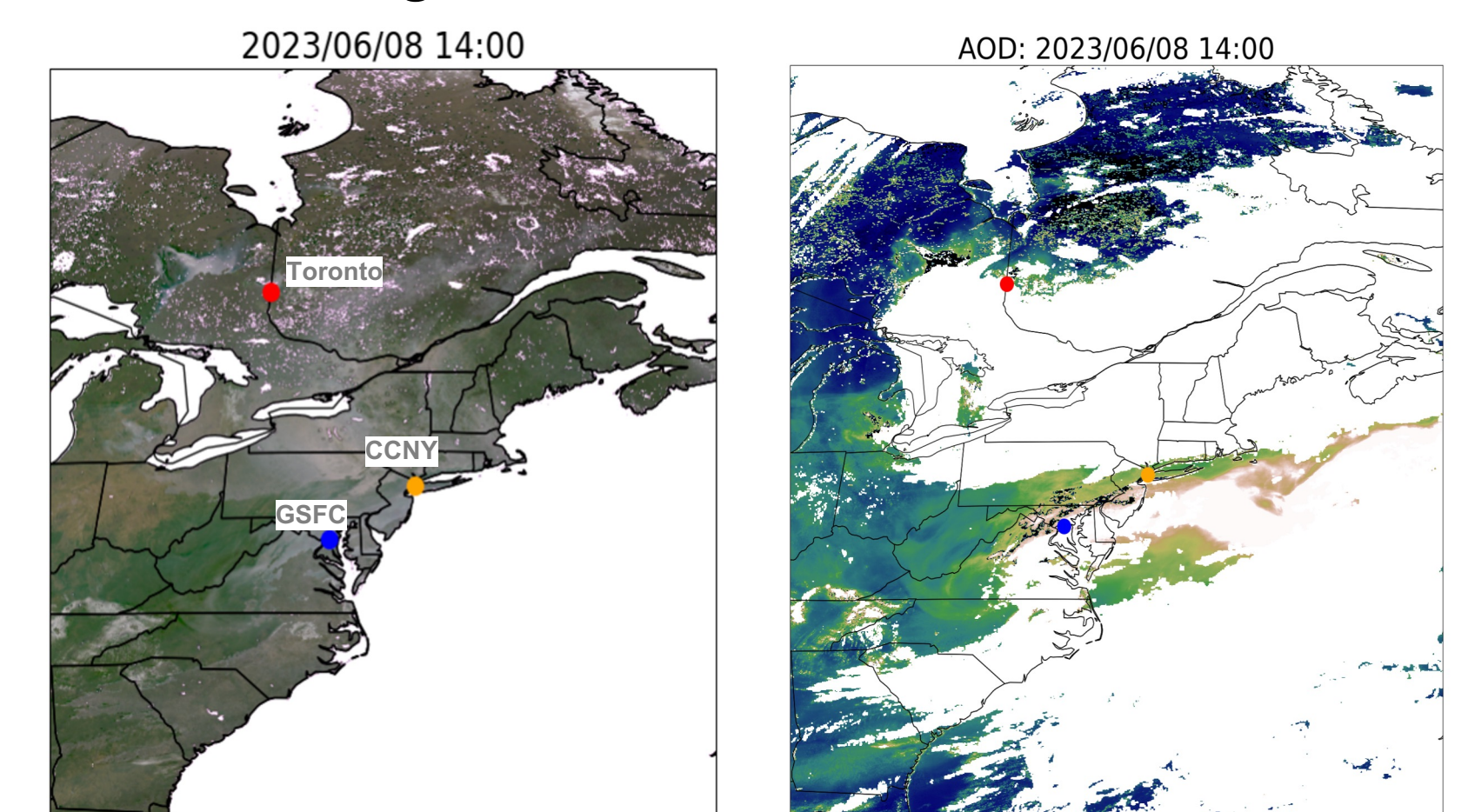
June 6th

- The smoke plume has shifted eastward across the U.S., with AOD readings in Toronto decreasing below 1.
- Meanwhile, New York and Baltimore are now experiencing smoke arrival, as indicated by AOD values exceeding 1.



June 7th

- Toronto's AOD continues to decline below 0.5 with skies.
- Smoke remains dense in the New York and Baltimore area, with AOD values exceeding 1.

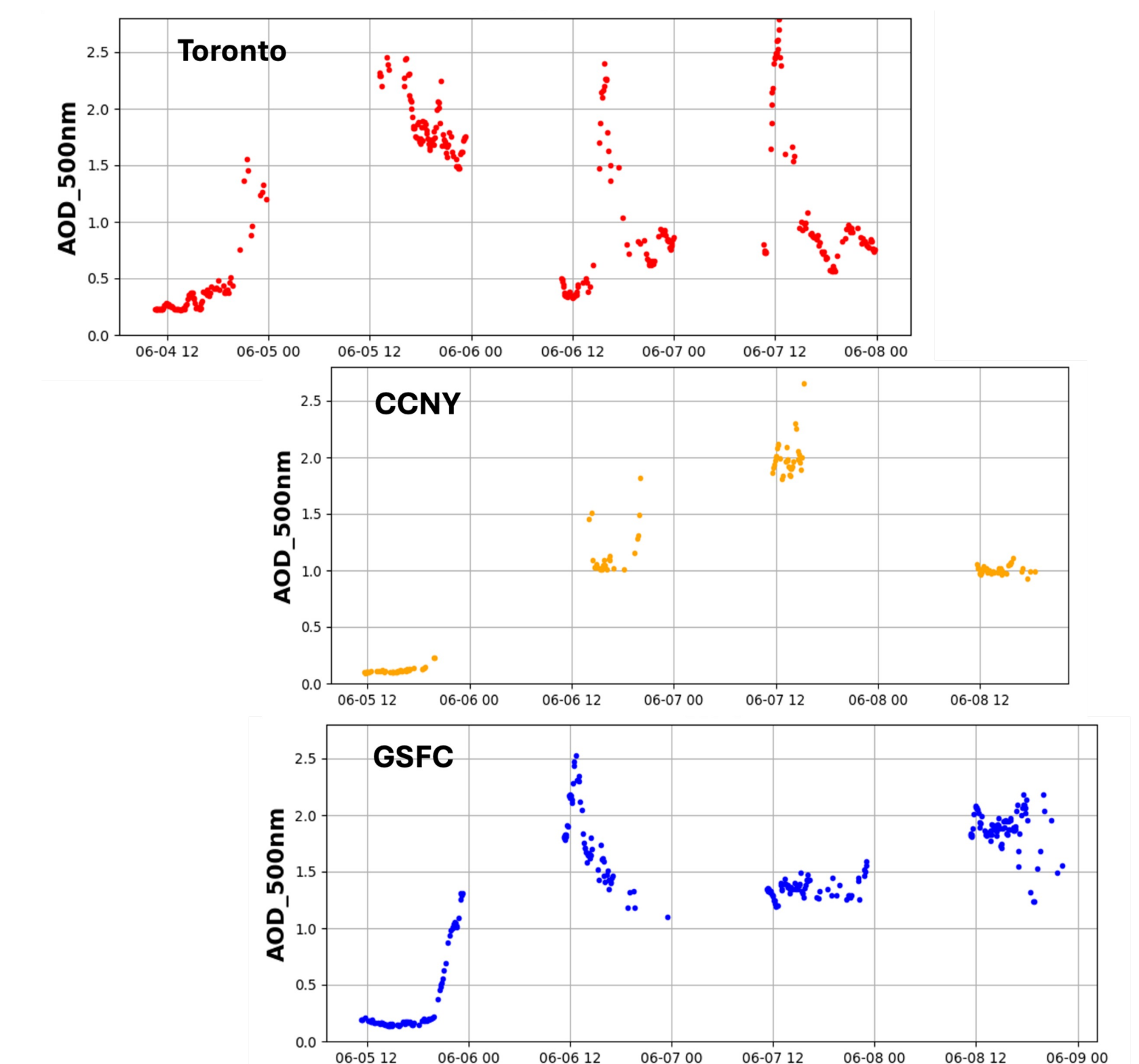


June 8th

- Toronto appears to be experiencing renewed smoke presence, with AOD values rising around 1.0.
- Smoke remains dense in the New York and Baltimore area, exceeding AOD 1.0.

RESULTS and CONCLUSIONS

- **Aerosol RObotic NETwork (AERONET)⁴**
 - a ground-based aerosol remote sensing network
 - Downloaded and plotted AERONET AOD using Python at three stations: Toronto, CCNY in New York City, and GSFC in Maryland.
 - Time series of AERONET AOD shows the smoke progression over five days. This confirms our GOES-R data findings, indicating a southward movement of smoke negatively impacting the Eastern U.S..



Summary

- We used GOES-R AOD and BRF products to track the smoke's path over Canada and Eastern U.S. during June 4th-9th, 2023; and used AERONET ground measurements at the Toronto, CCNY, and GSFC stations to verify the path of the smoke.
- GOES-R's high spatial and temporal resolution enables detailed analysis of smoke dispersion patterns.
- By tracking the evolution of smoke plumes, emergency responders and authorities can better anticipate the direction and extent of smoke impacts on nearby communities
- In the future, we plan to continue applying GOES-R data for further environmental studies.

References

1. Monthly_AQI_Baltimore_2023 at mde.maryland.gov https://mde.maryland.gov/programs/Air/AirQualityMonitoring/Documents/MonthlySummaries/Monthly_AQI_Baltimore_202306.pdf
2. GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Suspended Matter/Aerosol Optical Depth and Aerosol Size Parameter, https://www.star.nesdis.noaa.gov/atmospheric-composition-training/documents/ABI_AOD_ATBD_v4.3_20230131.pdf
3. GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Surface Albedo, https://www.star.nesdis.noaa.gov/goesr/documents/ATBDs/Enterprise/ATBD_Enterprise_Land_Surface_Albedo_v3_2020-10.pdf
4. Aerosol Robotic Network (AERONET), <https://aeronet.gsfc.nasa.gov/>