

Breaking Barriers: Integrating GEO-LEO Aerosol Data With an Open-Source Approach

Xiaohua Pan^{1,2}, Jennifer Wei¹, Sally Zhao³, Neil Gutkin⁴, Pawan Gupta¹, Robert Levy¹, Zhaohui Zhang^{1,2}

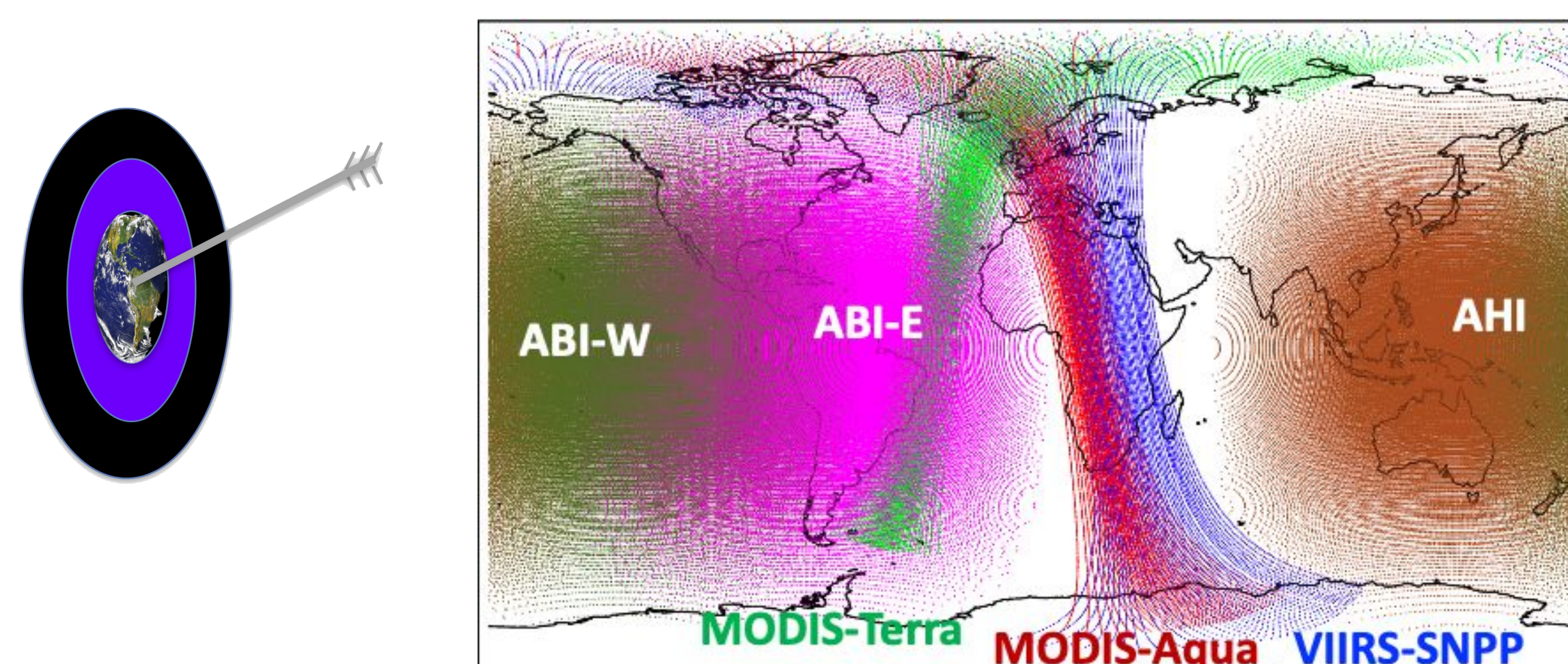
¹GES DISC, NASA Goddard Space Flight Center, Greenbelt, MD, USA ²ADNET Systems Inc., Lanham, MD, USA ³University of Maryland at College Park, MD, USA ⁴Virginia Tech **Contact:** xiaohua.pan@nasa.gov

1. Introduction

The scientific community is still examining the novel data from geostationary satellite observations and evaluating methods for effectively fusing the polar observations with various spatial and temporal resolutions. However, the merged data will present a significant "Big Data" challenge, including processing, storage, data discoverability, accessibility, and migration within cloud computing environments.

We have developed an open-source package to fuse aerosol optical depths (AOD) products from six satellite sensors in the past four years (2019~2023), and this presentation will update our recent progress. Using this Python-based package, we produced a level 3 (L3) global AOD product in a quarter-degree spatial resolution every half-hour, fusing the Level 2 (L2) AOD data with the Dark Target (DT) aerosol retrieval algorithm from six satellites (Levy et al., 2013, Gupta et al., 2020): three geostationary (GEO: GOES-16/17 and Himawari-8) with high temporal resolution, and three low polar orbiting (LEO: TERRA/MODIS, AQUA/MODIS, and SNPP-VIIRS) with global coverage. By integrating these observations, the diurnal cycle of global AOD in this fused product can be characterized at local, regional, and global scales. In this presentation, we will validate the fused level 3 global AOD product with AEROSOL ROBOTIC NETWORK (AERONET) L2 AOD data.

Joining GEO and LEO



2. Open-Source Approach

Furthermore, we are committed to openness and transparency by providing our package and its associated functionalities as open-source. We design this package following the NASA Scientific Information Policy to serve the public good (<https://science.nasa.gov/researchers/open-science/science-information-policy/>). Our dedication to adhering to the FAIR (i.e., Findable, Accessible, Interoperable, and Reusable) (Carroll et al., 2021) and TRUST (i.e., Transparency, Responsibility, User Focus, Sustainability, and Technology) principles ensures that our users can rely on the integrity and ethical standards of our work. For instance of Interoperability, this package fuses remote sensing products on demand into desired temporal and spatial domains. It can be run in a central processing unit (CPU) or a Graphics processing unit (GPU) mode. This package will empower researchers and practitioners to use satellite and sensor data efficiently in various applications and research.



3. L3 Gridded Product

This work is supported by NASA's Making Earth System Records Useful for Research Environments (MEASURES-2017) program. Product is known as **XAERDT**. Level 3 (L3) are produced on 0.25°x0.25° (Quarter Degree = QD) grid at 30-minute (Half Hourly = HH) intervals.

It includes statistics for:

- Sensor-specific AOD (both QA filtered - ocean (Average) (Quality flag = 1, 2, 3) and land (corrected) (Quality flag = 3) and all-quality for L2 quality assurance).
- Sensor-specific angles (view and scattering angles).
- Merged AOD at 550 nm.
- Merged angles (solar).
- Initial merge is "unweighted = no preference" although future versions may include weights.

For more information on DT and L2 products, please refer to

- **A23R-2612** by Robert Levy et al.

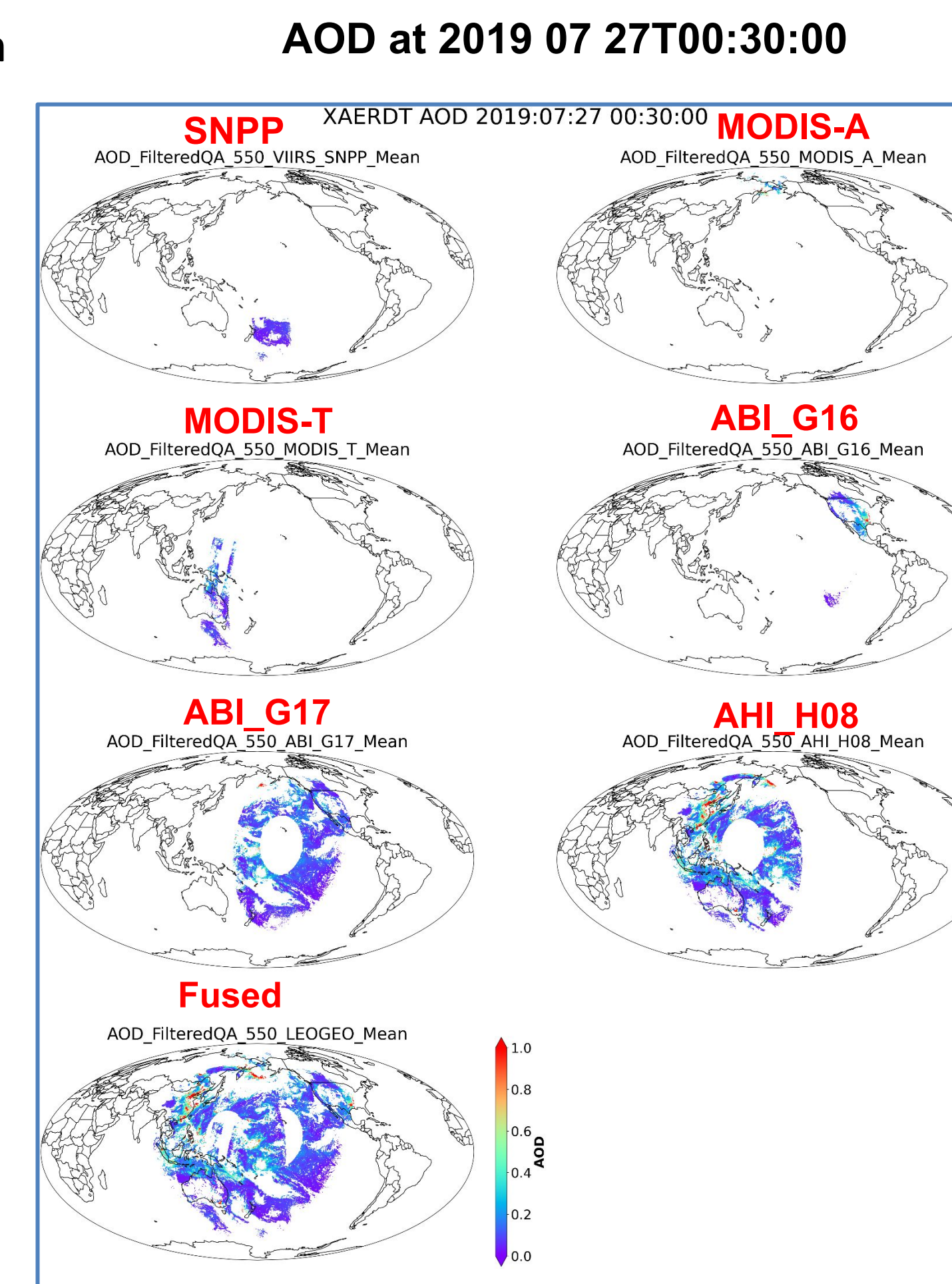


Figure 1 The 3 LEOs and 3 GEOs AOD at 550 nm with the filtered QA on 2019-07-27T00:30:00 and the corresponding fused L3 product (the bottom panel).

4. Validation of the L3 Fused AOD

XAERDT AOD_FilteredQA_550_LEO_GEO_Mean 20190727 Dailymean

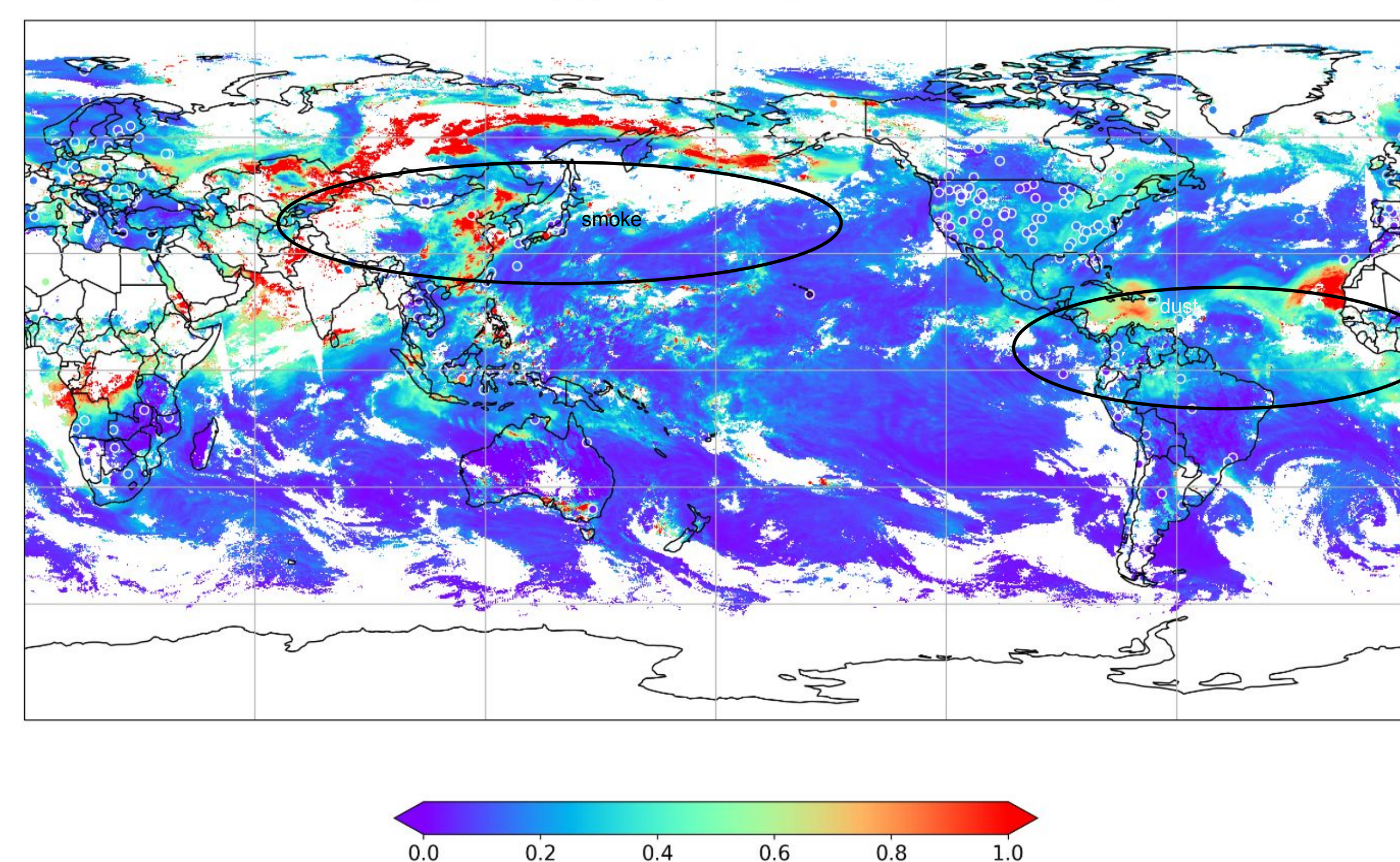


Figure 2 The daily mean of the fused AOD at 550 nm with the filtered QA on 2019-07-27. The daily mean of AERONET level 2 AODs are overlaid as dots. Two hotspots are highlighted with ovals, one highlighting the smoke plume outflow in Eurasia and the other highlighting the dust plume outflow in Africa.

References:

Carroll, S.R., Herzog, E., Hudson, M. et al. Operationalizing the CARE and FAIR Principles for Indigenous data futures. *Sci Data* 8, 108 (2021). <https://doi.org/10.1038/s41597-021-00892-0>.

Levy, R. C., S. Mattoo, L. A. Munchak, et al. 2013. The Collection 6 MODIS Aerosol Products over Land and Ocean. *Atmos Meas Tech* 6 2989-3034.

Lin et al., 2020. The TRUST Principles for Digital Repositories. *Scientific Data* <https://doi.org/10.1038/s41597-020-0486-7>

Gupta, P.; Remer, L.A.; Patadia, F.; Levy, R.C.; Christopher, S.A. High-Resolution Gridded Level 3 Aerosol Optical Depth Data from MODIS. *Remote Sensing*. 2020, 12, 2847. <https://doi.org/10.3390/rs12172847>.

4.1. The Overall Data Quality

AOD at 550nm (20190727-20190728)

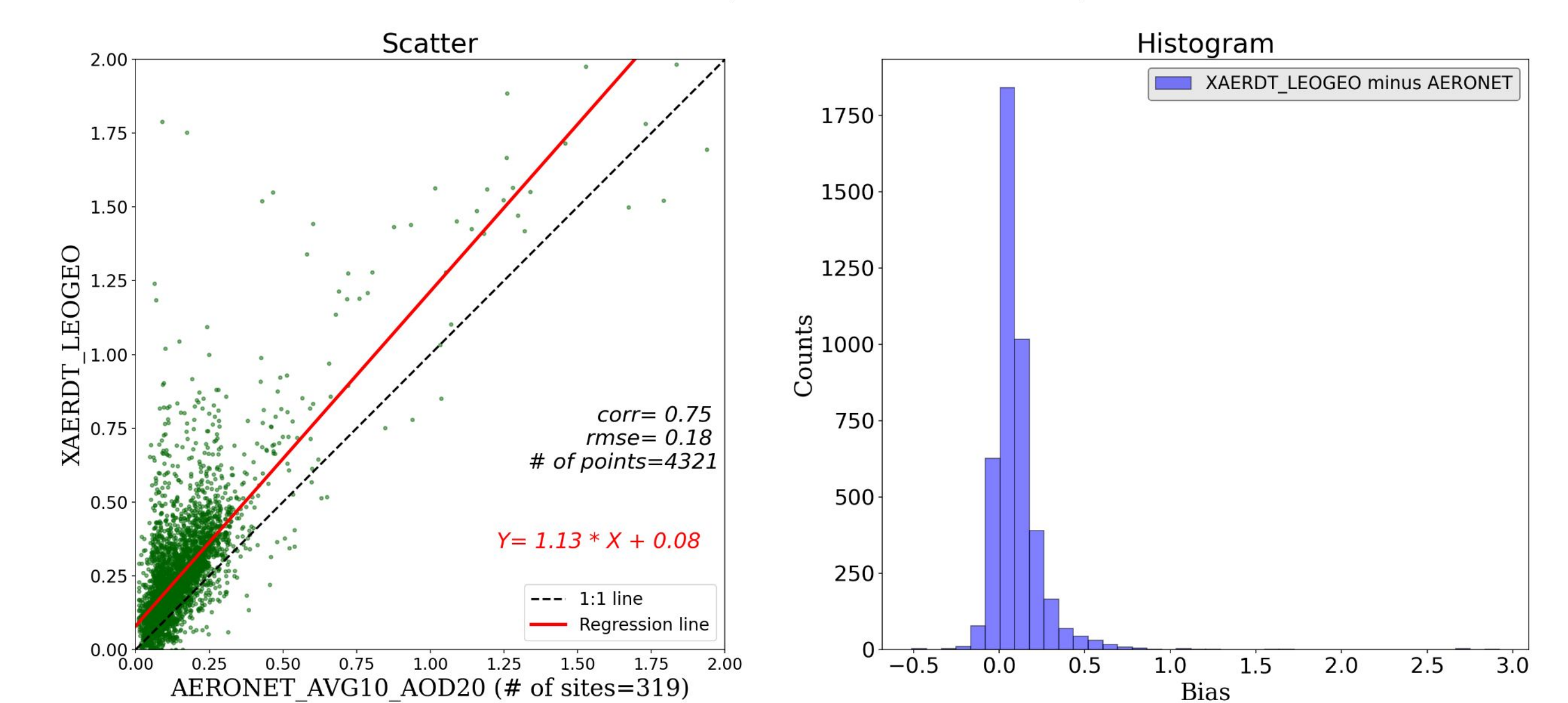


Figure 3 The scatter plot (the left panel) and histogram (the right panel) of the fused L3 AOD at 550 nm with the filtered QA (i.e., XAERDT_LEO_GEO) validated against the AERONET level 2.0 (i.e., AERONET_AVG10_AOD20) binned for every half hour on 2019-07-27 and 2019-07-28. Totally 4321 points are matched at 319 AERONET sites, collocated at the nearest location.

Summary: On July 27-28, 2019, the fused AODs at 550 nm with the filtered QA (XAERDT) concentrated within 0-0.5 and showed a relatively high linear correlation with the AERONET level 2 AOD, with a correlation of 0.75. In general, XAERDT_LEO_GEO is biased high, with a root mean square error of 0.18.

4.2 Diurnal Cycles of AOD at AERONET Sites

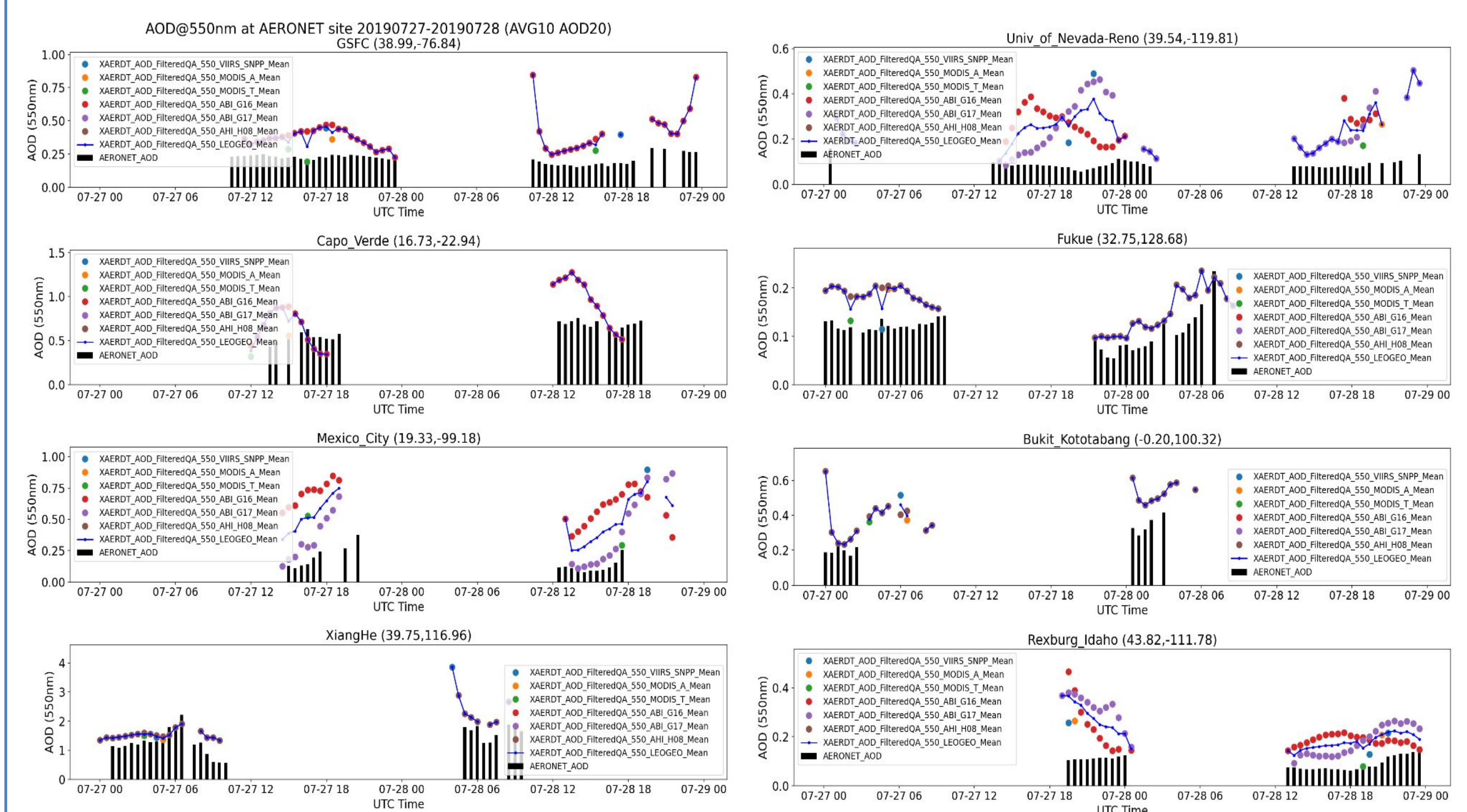


Figure 4 The diurnal cycle of the fused, 3 LEOs, and 3 GEOs AOD at 550 nm with the filtered QA validated against the AERONET level 2 binned for every half hour on 2019-07-27 and 2019-07-27 at eight selected AERONET sites.

Summary: The fused AODs provide continuous daily measurements, mainly attributed to 3 GEOs. GEOs are often biased higher than LEOs against AERONET. ABI_G16 and ABI_G17 do not agree very well at the selected sites. An in-depth investigation is needed to understand the discrepancies further.