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Using Novel Machine Learning Algorithms to Improve the Spatiotemporal Coverage of Satellite Aerosol Optical Depth

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Abstract Text:

Satellite-based estimates of particulate air pollution offer a global view of climate change and human health risk assessments. However, the Aerosol Optical Depth (AOD) products retrieved from satellite remote sensing suffer from artifacts (i.e., overestimated AOD) or are of low quality when collected over very bright surfaces such as deserts. Another challenge is the extensive missing data in AOD from satellite retrievals, especially on a daily basis, due to cloud or snow cover, which impairs the spatial-temporal coverage in observing the global distribution of aerosols. In the western U.S., daily AOD from satellite retrievals are associated with a large number of abnormally high values and spatial gaps; therefore satellites fail to provide sufficient smoke transport information when fire events occur.

In this study, we explored large wildfire events [i.e., Rim Fire (2013), King Fire (2014) and Tubbs Fire (2017)] during the 2013-2017 wildfire seasons in semi-arid regions using the Moderate Resolution Imaging Spectroradiometer (MODIS) – Terra/Aqua Dark Target (DT) and Deep Blue (DB) aerosol products. After the significant AOD artifacts caused by high surface albedo were corrected using a newly developed statistical method, we leveraged novel Tensor Completion Algorithms (TCAs) to fill daily AOD gaps in MODIS data. Smoke-plume injection heights, meteorological variables, land use, and population data were used as constraints to improve smoke data completion in the TCAs. The gap-filled AOD values using the novel TCAs approach demonstrated enhanced performance in capturing the large-scale spatial and temporal variability compared with Kriging (a commonly used spatial interpolation method). The methods developed in this study can be used to create a long-term artifact corrected and gap-filled daily AOD dataset for use in statistical data fusion frameworks to estimate surface pollutant concentrations.

Session Selection:
Advances of Atmospheric Remote Sensing Inversion

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Abstract Title:
Using Novel Machine Learning Algorithms to Improve the Spatiotemporal Coverage of Satellite Aerosol Optical Depth

Requested Presentation Type:
Assigned by Program Committee (oral or Poster)

Previously Published?:
No

AGU On-Demand:
Yes

Abstract Payment:
Paid (agu-fm19-503441-1554-0534-9792-0905)

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