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REGIONAL ESTIMATES OF GROUND LEVEL AEROSOL USING SATELLITE REMOTE SENSING AND MACHINE-LEARNING

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1. INTRODUCTION

The estimation of aerosol can lead us to better assessment of the air quality information as well as supply insights into the understanding of the climate change. Aerosol optical depth (AOD) is widely used parameter used to quantify aerosol abundance. The satellite remote sensing provides aerosol optical depth (AOD), which we show to have biases. Specifically, the bias is high in the urban areas, where the aerosol can have more severe effects on public health due to exposures. While the general MODIS algorithm is fairly robust, especially in the North East, new challenges are emerging as the spatial resolution of the AOD product is reduced to 3km. In particular, larger sensitivity to surface properties is expected which is magnified in urban areas.

To assess satellite retrievals of these high resolution 3 km products, we use the summer 2011 Dragon AERONET data to assess accuracy as well as major retrieval bias that can occur in the MODIS measurements. In particular, we confirm the results of previous studies where the land cover (urban fraction) appears to be a strong factor in AOD bias and develop a Neural Network (NN) estimator which includes land cover directly.

2. DATA AND METHODOLOGY

We used the high-resolution 3km MODIS collection 6 data, and the summer 2011 Dragon AERONET data [1]. These MODIS data are collocated to the ground station with in the 2 hours before and after the MODIS satellites pass, and are averaged within the 0.05 degrees. As seen in the figure 1, the high resolution data has bias when compared with the AERONET data. This is not surprising because in the previous studies we have shown the existence of high bias in AOD retrievals in the collection 5 algorithm [2]. The bias is severe for urban areas such as New York City and other megacities [3].

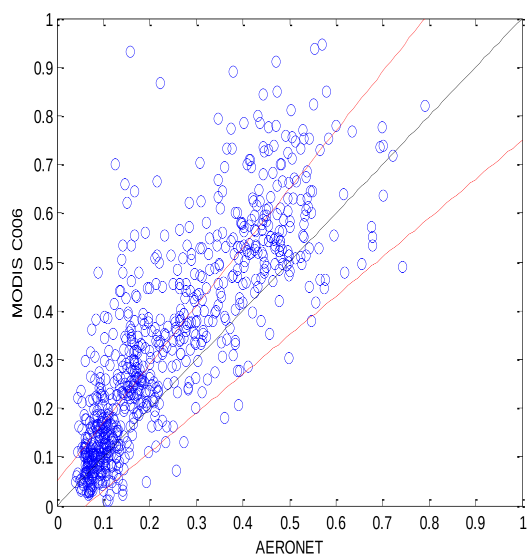

Figure 1. MODIS C006 data compared with the AERONET data shows the bias between these two measurements.

Therefore, by combining the AERONET with MODIS observations over sufficiently clean days, we compute the corrected land surface model thereby obtaining the bias-corrected

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AOD for the region. The observed bias can also be corrected by using machine-learning techniques. We implemented a NN method to obtain the bias-corrected AOD.

3. RESULTS

3.1 Insights from the Anomalies in Spectral Ratios

The Aerosol Retrieval over land is greatly affected by land surface albedo. MODIS land surface compensation algorithms for global applications were trained using non-urban land surface types (mixtures) such as vegetation/clays. Different kind of land usage results into the anomalies in spectral ratio, and the differences in land surface behavior need to be better understood as urbanization continues to increase. For example, figure 2 shows anomalies in the surface reflectance ratio which correlates with the urban and broadleaf forest types. These issues become even more significant for higher resolution aerosol products such as C006 3km Aerosol Retrievals.

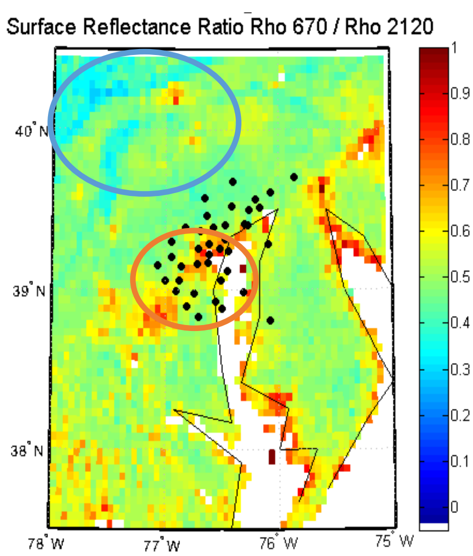

Figure 2. Anomalies in the Surface Reflection Ratio shows the distinct features which corresponds to the land-use. Therefore, it should be an important factor in the resulting bias.

We combined the AERONET with MODIS observations over sufficiently clean days, computed the corrected land surface model, and then obtained the bias-corrected AOD for the region. Figure 3 shows one example for July 29, 2011. The local AERONET stations with the corresponding AOD readings have been presented, which can be compared with the MODIS regionally tuned AOD product showing very good correspondence with each other.

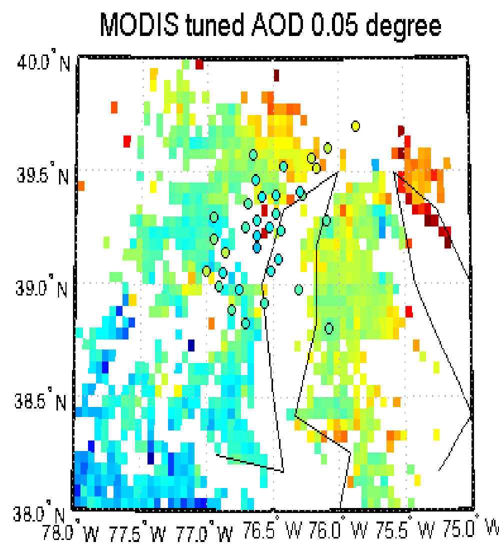

Figure 3. MODIS tuned AOD product shows good agreement with the AERONET AOD data.

3.2 Implementing Neural Network

We constructed a machine-learning framework to estimate and corrected the bias with respect to the ground station AOD data. Specifically, we used neural network for the observed bias correction. The NN was trained in regression mode with the following inputs: AOD at 550, Surface Reflectance at 470, 660, 2130 nm, Scattering Angle, Latitude, Longitude, and land class. Figure 4 shows the result of the bias corrected MODIS AOD product. In order to demonstrate the robustness of the neural network, we also show the testing and training data, which are consistent with each other.

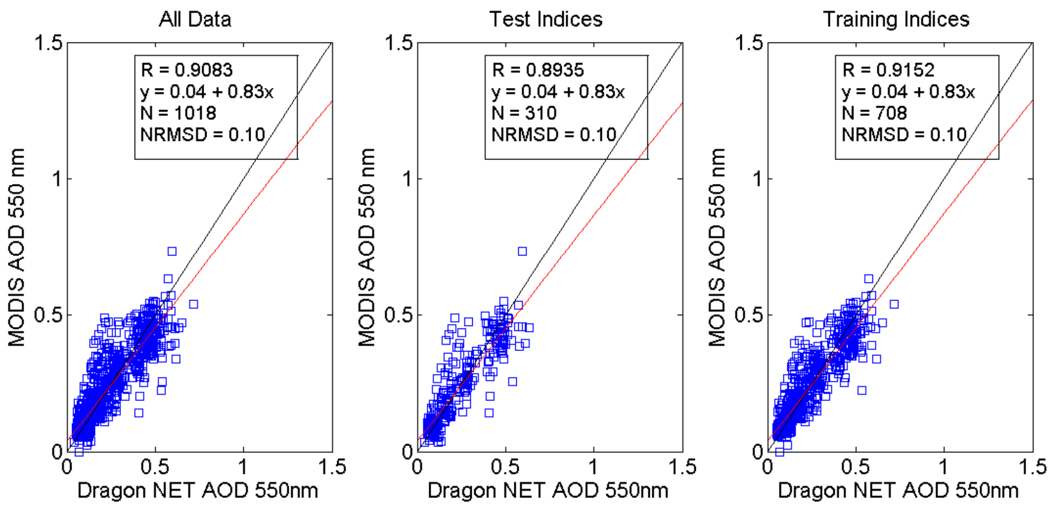

Figure 4. Neural Network Bias Correction applied to the MODIS AOD data. The central and right subplots show the testing and training data partition, which are consistent with each other, resulting into the high correlation in the total data (left).

6. CONCLUSIONS

We used the high-resolution 3km MODIS collection 6 data, and the summer 2011 Dragon AERONET data to assess the retrieval bias in the MODIS measurements. In particular, the land cover (urban fraction) appears to be a strong factor in AOD bias. Therefore, we developed a NN estimator which includes land cover directly and obtained bias-corrected AOD product.

7. ACKNOWLEDGMENTS

We would like to thank the NASA Collection 6 team for supplying the data. This project was made possible by the National Oceanic and Atmospheric Administration, Office of Education Educational Partnership Program award NA11SEC4810004. Its contents are solely the responsibility of the award recipient and do not necessarily represent the official views of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).

8. REFERENCES

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