Validation of the New Collection of MODIS Aerosol Retrievals Against Ground-based Measurements

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Introduction

Aerosol retrievals over land are a major challenge and to date, only a handful of such products are available. The MODerate resolution Imaging Spectroradiometer (MODIS) currently provides the most extensive aerosol retrievals on a global basis, but validation is limited to a small number of ground stations. This study presents a comprehensive evaluation of Collection 4 and 5 MODIS aerosol products using ground measurements from the hand-held sunphotometer in China. The Collection 5 product uses a new algorithm to determine the surface reflectance and a new aerosol model to retrieve aerosol optical thickness (AOT). Development of this new product employed ground data from the Aerosol Robotic Network (AERONET) but did not include data over China hence the evaluation performed in this study is independent. Here we present some statistic results of overall comparison, comparison over different land surface conditions and also try to address the possible reasons of good agreement or large bias.

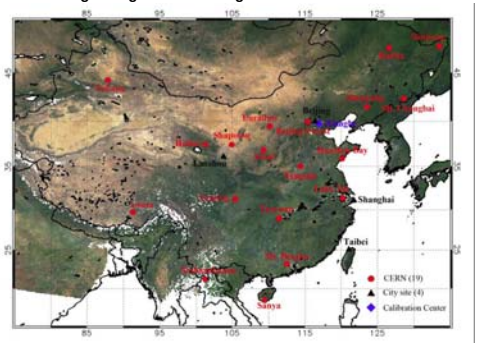


Figure 1. Location of Hazemeter sites in China

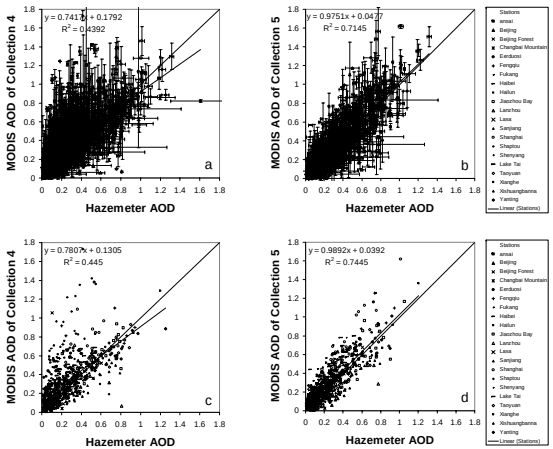


Figure 2. Comparison of MODIS AOT from C4 (left) and C5 (right) with ground-based Hazemeter measurements made at all Hazemeter stations. The bars in the top two panels denote the standard deviations computed over the spatial (MODIS) and temporal (Hazemeter) domains. The lower two panels show the same comparisons but for selected data based on standard deviation.

Overall, the correlation coefficient of regression with ground measurements increased from 0.66 to 0.84 for all data points. The offset is reduced from 0.1792 to 0.0477, and the slope is improved from 0.7417 to 0.9751.

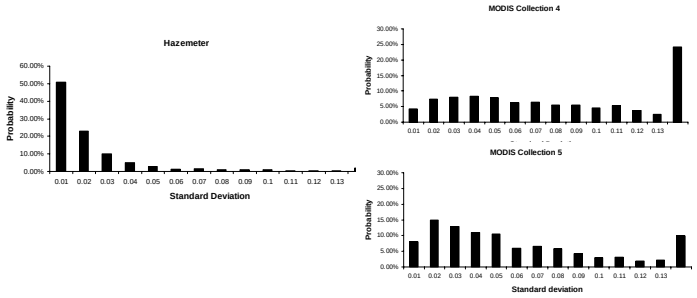


Figure 3. Histograms of the probability of occurrence for the standard deviation of AOD from hazemeters, and MODIS collection 4 and 5 data.

The SDs from the two MODIS products are substantially larger than that from the hazemeters, while SDs from the C5 are significantly smaller than the C4. If we limit our analyses to SD<0.05 for hazemeter data, and SD<0.1 for MODIS data, the agreements between satellite retrievals and ground observations would be improved, as seen from the lower two panels of Figure 2.

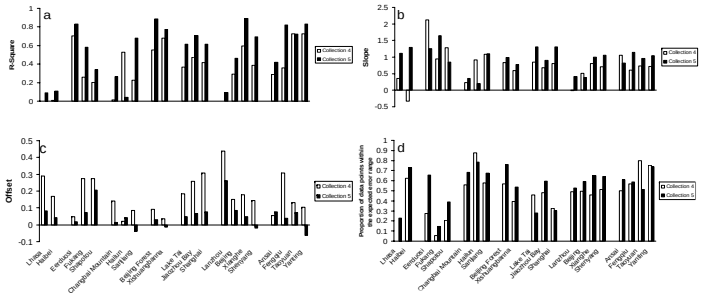


Figure 4. The statistics of linear regressions between MODIS and hazemeter data at individual sites: the square of the correlation coefficients (a), slope (b), offset (c). (d) The probability of data falling within the expected error range.

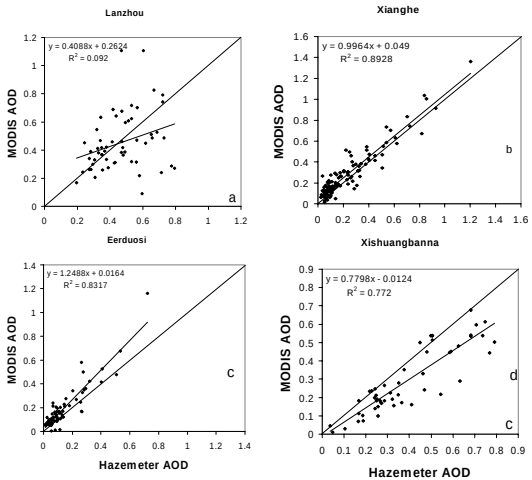
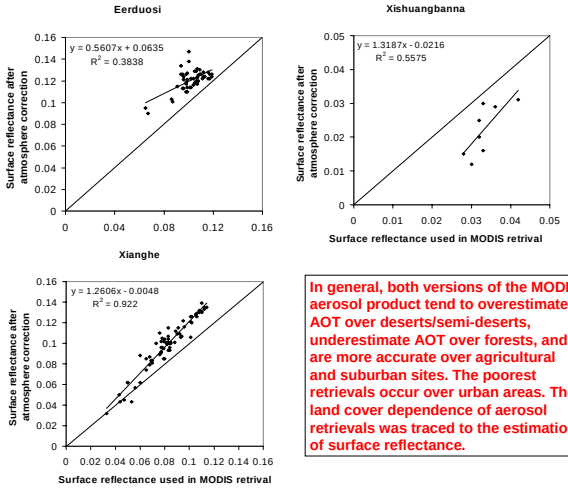


Figure 5. Comparison between MODIS and Hazemeter AOTs for urban site (a), agricultural and suburban site (b), desert and semi-desert site (c) and forest site (d).



In general, both versions of the MODIS aerosol product tend to overestimate AOT over deserts/semi-deserts, underestimate AOT over forests, and are more accurate over agricultural and suburban sites. The poorest retrievals occur over urban areas. The land cover dependence of aerosol retrievals was traced to the estimation of surface reflectance.

Figure 9. Comparisons between AOT from MODIS C4 (left), C5 (middle) as a function of hazemeter AOT, with reference to the comparison of surface reflectance.

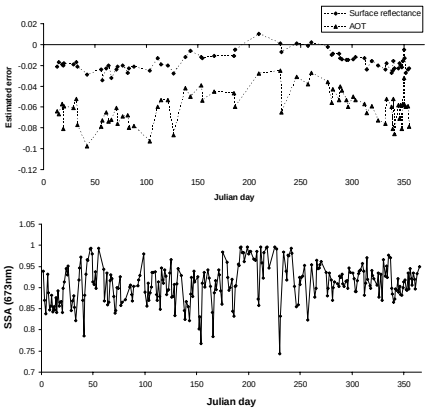


Figure 10. Time series of the error of AOD and surface reflectance and SSA in 2005 at Xianghe site

The fine-dominated aerosol modes were assigned a 'neutral' absorption (SSA~0.90) for all seasons across China, except for a narrow strip along the eastern China Sea. Although such simplification is necessary due to a lack of measurements of ω0. In reality, ω0 varies rather dramatically as indicated by the time series of ω0 estimated from a Cimel sunphotometer in Xianghe.

Summary

Substantial improvement was found in the Collection 5 AOT product relative to the Collection 4 AOT product. The improvement varies with surface and atmospheric conditions. The land cover dependence of aerosol retrievals was traced to the estimation of surface reflectance. The selection of the aerosol type is another major factor contributing to the discrepancies. Errors caused by both factors are subject to considerable variations with season and location due to land cover changes and varying fractions of coarse and fine mode aerosols, as well as the changing amount of scattering and absorbing aerosols.

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