

COMPARISON OF MODIS AND AERONET AEROSOL OPTICAL THICKNESS OVER TAIWAN

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ABSTRACT: In this work we report the MODIS aerosol optical thickness (AOT) product and the point measurements of AOT at the four AERONET stations over Taiwan. The ground based AERONET observations are used to compare and validate the satellite derived MODIS AOT product. Using the observations taken during the cloud free days in the period from 2002 to 2007, the long-term and seasonal variations of AOT over Taiwan are reported and discussed.

1. INTRODUCTION

Aerosols play significant role in the global climate system, both directly and indirectly, by scattering the short wave solar radiation reaching the surface and also by trapping the out going long wave radiation (Myhre et al., 2007; Bellouin et al., 2005). Though there are global models of the direct radiative forcing of aerosols at the top of the atmosphere, the uncertainties in the aerosols distribution and properties influence such estimates. Bellouin et al. (2005), using satellite and ground measurements of aerosol optical thickness (AOT), showed that the clear sky global annual average of the direct radiative forcing at the top of the atmosphere by aerosols is about -1.9 ± 0.3 W/m², which is more than the model predictions. Thus, accurate aerosol measurements are necessary for more reliable calculations of the radiative effects.

Satellite observations are best suitable for the continuous global monitoring of aerosol properties. The MODERate Resolution Imaging Spectroradiometer (MODIS) onboard Terra and Aqua satellites, with 36 spectral bands, provides global coverage of aerosol products with moderately high spatial resolution. Considering the uncertainties involved in the aerosol measurements and the limitations of the algorithms used, it is necessary to compare the satellite observations with that from other techniques. AERONET is a global network of ground based sun/sky scanning radiometers that provides highly accurate AOT values, and has been widely used for validating satellite data (Chu et al., 2002). The primary goal of this work is to compare the MODIS AOT products over Taiwan with that from the four AERONET stations. Using the time series of AERONET and MODIS data, the long-term trends and seasonal patterns of AOT over Taiwan is described.

2. DATA AND METHODOLOGY

The daily Level 2 MODIS AOT products during the years 2002-2007 and the level 2 AERONET AOT values from the four stations across Taiwan during 1998-2007 are used in this work. The MODIS values are available at 550 nm while the AERONET data at 440 and 670 nm are interpolated to find the value at 550 nm. The values greater than 1 are removed to avoid any possible cloud contamination and monthly and yearly means are computed. The MODIS AOT product is available for a grid of 10 km resolution, while the AERONET gives the values at a particular location. Thus, the MODIS measurements are interpolated to calculate the value corresponding to the AERONET location by fitting a longitude-latitude-AOT plane over the

region covering the AERONET as described by Ichoku et al. (2002). Also, the AERONET measurements before and after the MODIS overpass are interpolated to get the AERONET AOT at the time of MODIS observation.

3. RESULTS

Figure 1 shows the scatter plot between AERONET and MODIS AOT values that match spatially and temporally, during 2002 to 2006. Note that there is an overall good agreement between the two AOT values with the slope of the linear fit approaching unity. The correlation between the points is about 0.8, which would be even better if not for the two or three scattered points. The good correlation of the AERONET AOT with the corresponding MODIS data gives confidence in using the MODIS measurements over the locations where ground measurements are not available.

The coincident measurements from MODIS and AERONET are used to study the long-term climatology of AOT over Taiwan. Figure 2 displays the annual mean AOT values during the years 2002 to 2006, with the values ranging from 0.25 to .5. Though both the measurements slightly differ, the offset is very small. The MODIS AOT is less than the corresponding AERONET value in 2006. MODIS gives slightly higher values in 2002 and 2005, while the agreement is much better in 2003 and 2004. It can also be seen that both the MODIS and AERONET observations show a decreasing tendency with a rate of decrease of about 0.0375 units per year.

Figure 3 gives the seasonal variation of MODIS AOT from 2002 to 2006. The seasonal variation shows a double peak pattern with maximum values in the months of February-March and a less pronounced secondary maximum during September-October. Note that the secondary peak appears less significant in the years 2003, 2005, and 2007. Also, in 2003 the first peak appears in April-May months. The AOT reach minimum values during June-July and November-December, respectively.

4. DISCUSSION

Though MODIS data are available for a period of 5 years and AERONET data for 9 years, there are only very less number of observations where the time and location of the measurements are coincident. Nevertheless, the comparison of the MODIS and AERONET AOT values in Figure 1, in general agrees with the previous reports (Chu et al., 2002; Cheng et al., 2006). While carrying out an inter-comparison of various satellite measurements of AOT together with ground measurements, Myhre et al. (2005) noted that the MODIS and AERONET values disagree over Taiwan, and such disagreement was reported in general over oceanic regions. The better results in the present study could be because of the better spatial and temporal matching of both the observations. Further comparisons are underway using the AERONET measurements from more stations.

The annual mean AOT values over Taiwan show higher values than the global mean values reported by Mishchenko et al., (2007) for the corresponding years. Also, their results do not show any clear decreasing trend. Cheng et al., (2006) reported the AOT values over Hong Kong during 2002 to 2004, which showed values slightly higher than that reported over Taiwan. More over, they noted an increasing trend in the AOT values. The observed decrease over Taiwan could be partially due to the strict emission controls in practice, while the rapid industrialization in Hong Kong and China could account for the higher AOT values there. The results show that it is important to have local measurements of aerosol properties to understand its radiative

effects on regional and global climate. Over Taiwan, a region surrounded by ocean, the marine aerosols contribute significantly to the total amount. Another major source is the dust transport from China and Mongolia (Lin, 2001). In a recent study, Chou et al., (2007), reports that the Asian outflow events carry anthropogenic pollutants such as sulphate, ammonium etc. The higher values of aerosols compared to that of remote areas is attributed to such transport events.

The seasonal variation of AOT shows almost consistent pattern in all the years, and agrees well with that reported by Cheng et al., (2006) over Hog Kong. The May to June period is the rainy season in Taiwan and July to October months often witness strong typhoons. Thus, the minimum AOT values could result from the heavy rainfall in this period. In the winter months also the Northern parts of Taiwan receives significant rainfall. More over the winds are stronger in this season.

5. SUMMARY

The ground based AERONET AOT values over Taiwan show good correlation with those from the MODIS measurements. The seasonal variation shows peak values during February-March and August-September months and minimum values during Jun-July and November-December months. The annual mean AOT values from both MODIS and AERONET during the years 2002-2006 exhibit a decreasing trend.

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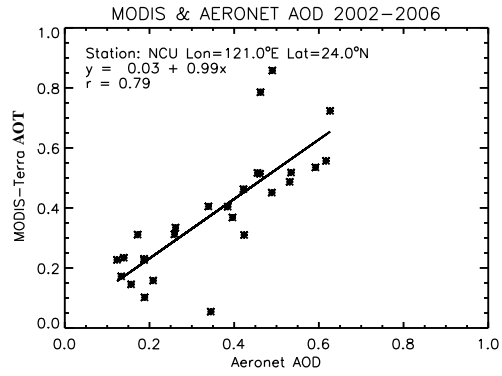


Figure 1. The scatter plot of annual mean AOT values from AERONET and MODIS at 550 nm during 2002-2006. The solid line is the linear fit of the data points.

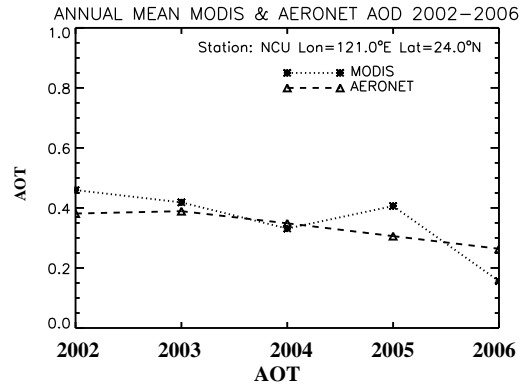


Figure 2. The annual mean AOT values from AERONET and MODIS at 550 nm during 2002-2006.

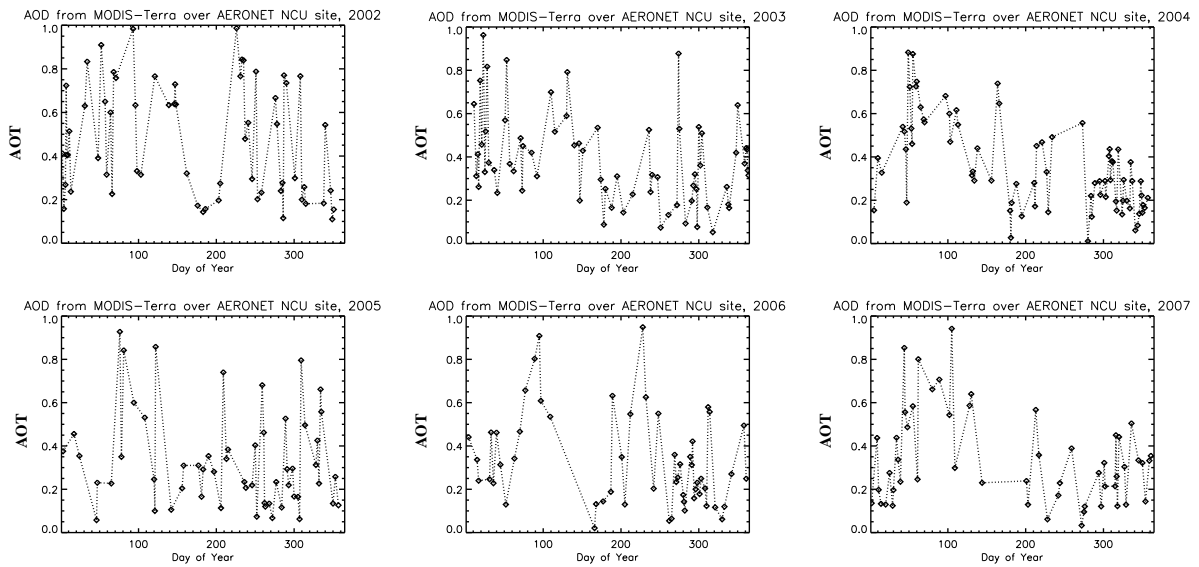


Figure 3. Seasonal variation of MODIS AOT values during 2002-2007.