# Concurrent Observation of Atmospheric Aerosol Optical Properties between Landsat-8 Satellite and Ground Instruments

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***Abstract* :** A concurrent observation between Landsat-8 satellite and ground instruments in Kanto area has been carried out for characterizing atmospheric aerosol optical properties in spatial distribution. In this study, aerosol parameter near the surface level are measured using plan position indicator (PPI) lidar which is operated at 349 nm to obtain spatial distribution of aerosol extinction coefficient (AEC). To solve lidar equation using Fernald methods, the lidar ration is determined from ground instruments (a nephelometer, an aethalometer, and an optical particle counter) through Mie scattering calculation. On the other hand, the visible band of Landsat-8, in this case we used band-2 with the center wavelength 482 nm, to determine spatial distribution of aerosol optical thickness (AOT). In computing radiative transfer derived from satellite sensor, we employ the MODTRAN code using the original aerosol type of Mie scattering calculation and AOT of sunphotometer.

***Keywords* :** PPI-lidar, Landsat-8, sunphotometer, AOT, AEC, Fernald methods, MODTRAN, Mie scattering.

## 1. Introduction

An indispensable effect atmospheric aerosol both directly and indirectly to the atmosphere has been discussed in the context of the earth radiation budget and global climate change [1]. Therefore, the precise measurement of atmospheric aerosol parameters is important for increasing better understanding their real characteristics especially in the lower troposphere.

One of significant parameter is aerosol extinction coefficient (AEC) which is correlated to the attenuation of light due to aerosol particle size floating in atmosphere and hygroscopicity parameter related to relative humidity [2]. The extinction coefficient is linear summation between absorption and scattering. Besides, The aerosol optical thickness (AOT) measured using a sunphotometer provides parameter related to the attenuation of solar radiation from the top of atmosphere to the ground level [3].

In this study, we explore a new monitoring technique by concurrent observation of PPI lidar and Landsat-8 satellite sensor to retrieve spatial distribution of AEC and AOT, respectively.

## 2. Methods

In this study, we employ band-2 (482 nm) of Landsat-8 satellite for confirming the wavelength of PPI lidar (349 nm) measurements. The plan area of both observation is in Kanto area at Center for Environmental Remote Sensing - Chiba University (35°37'30'' and 140°06'14''). This observations are carried out on March 20 and May 23, 2017 under clear sky condition.

The AEC in boundary layer is calculated and corrected using the procedure in ref [4]. The lidar ratio which is defined as the ratio between the extinction and backscattering coefficients is calculated using Mie scattering formulation based on the data of ground-sampling instruments (scattering, absorption, and particle size) [5]. The inversion analysis of PPI lidar signals is attained using the Fernald method [6], [7] to obtain AEC on a nearly horizontal plane.

By governing Lambert-Beer law, AOT can be derived from sunphotometer data. In AOT calculation, the aerosol loading is determined using Langley extrapolation method by linearization of Beer's Law equation [8]. In the Langley plot analysis for the calibration, the solar intensity is retrieved from the sunphotometer data in most clear sky condition in February 12, 2017.

In the present work, we mainly use MODTRAN-5 [9] for the analysis of Landsat-8 imagery by inputting AOT of sunphotometer. Also, the resulting aerosol parameters of Mie scattering calculation are used in the radiative transfer calculation for processing the Landsat-8 OLI data.

## 3. Results and Discussion

The main purpose of this novel monitoring technique are comparison of AEC distribution derived from PPI lidar (Figure 1) and AOT distribution obtained from band-2 of Landsat-8 satellite sensor (Figure 2). The lower AEC distribution is in May 23, 2017 (Figure 1 segment-B). The condition is confirmed to aerosol loading based on spatial distribution of AOT as the space looking by satellites in Figure 2 segment-B where

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at that time the AOT distribution is lower than in March 20, 2017. The condition confirm the theoretical concept that the AEC is the attenuation of light due to aerosol particle floating in atmosphere. As a results, the higher the AEC, the higher the AOT.

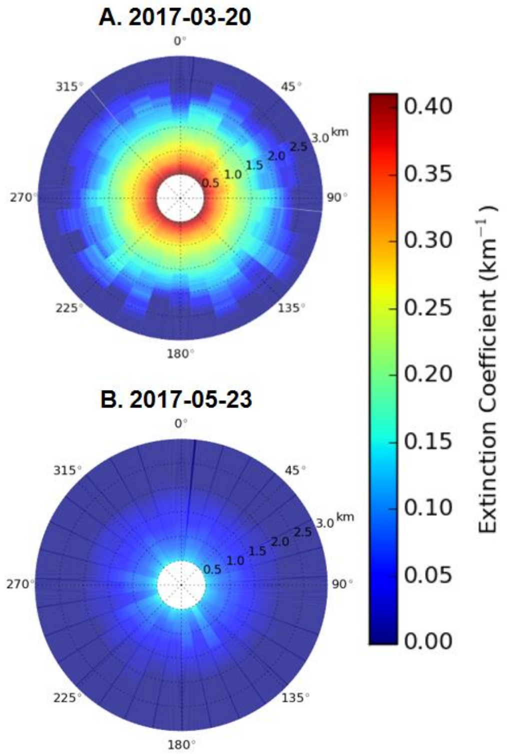


Fig. 1. Spatial distribution of AEC derived from PPI lidar using Fernald method.

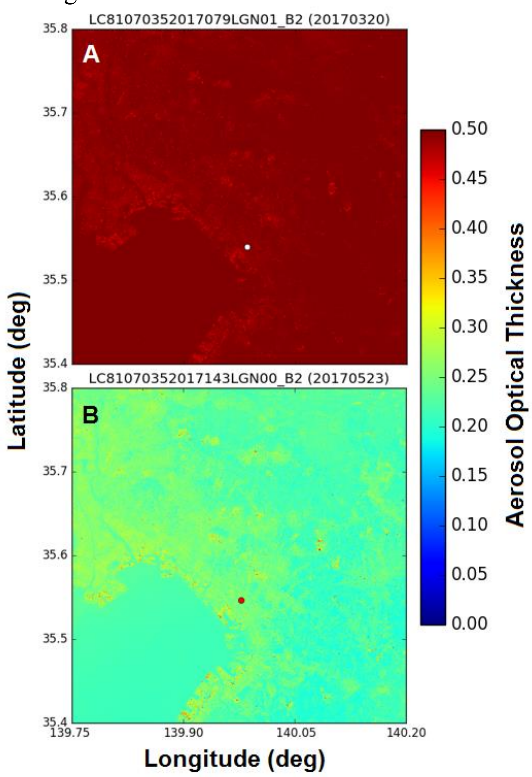


Fig. 2. The AOT's distribution derived from band-1 of Landsat-8 satellite.

## 5. Conclusion

In this monitoring technique, we seek that Aerosol optical properties observed in this monitoring techniques show us a consistence between surface and surface observation. In the surface measurement using PPI lidar inform us the trend of AEC distribution which is confirmed to the AOT distribution of space observation using Landsat-8 satellite sensor with the same blue band. The condition confirm the theoretical concept that the AEC is the attenuation of light due to aerosol particle floating in atmosphere where the higher the AEC, the higher the AOT.

**Acknowledgement**

One of the authors (JA) as a first author would like to thank the fellowship (BEASISWA DIKTI) from Directorate General of Resource for Research, Technology and Higher Education (DG-RSTHE), the Ministry of Research, Technology, and Higher Education Republic of Indonesia.

**References:**

[1] IPPC, "Climate Change 2007 : The Physical Science Basis," Geneva-Switzerland, 2007.

[2] P. Zieger, R. Fierz-Schmidhauser, E. Weingartner, and U. Baltensperger, "Effects of relative humidity on aerosol light scattering: Results from different European sites," *Atmos. Chem. Phys.*, vol. 13, no. 21, pp. 10609–10631, 2013.

[3] H. Kuze, "Multi-Wavelength and Multi-Direction Remote Sensing of Atmospheric Aerosols and Clouds, Remote Sensing - Applications," in *InTech, Available from:*, D. B. Escalante, Ed. In Tech, 2012, pp. 279–294.

[4] J. Aminuddin, S. Okude, N. Lagrosas, N. Manago, and H. Kuze, "Real Time Derivation of Atmospheric Aerosol Optical Properties by Concurrent Measurements of Optical and Sampling Instruments," *Open J. Air Pollut.*, vol. 07, no. 02, pp. 140–155, 2018.

[5] H. Kinjo, H. Kuze, T. Takamura, M. Yabuki, and N. Takeuchi, "Determination of aerosol extinction-to-backscattering ratio from multiwavelength lidar observation," *Jpn. J. Appl. Phys.*, vol. 40, no. 1, pp. 434–440, 2001.

[6] F. G. Fernald, "Analysis of atmospheric lidar observations: some comments.," *Appl. Opt.*, vol. 23, no. 5, p. 652, 1984.

[7] H. Kuze, "Characterization of tropospheric aerosols by ground-based optical measurements," *SPIE Newsroom*, pp. 2–4, 2012.

[8] J. G. Cerqueira, J. H. Fernandez, J. J. Hoelzemann, N. M. P. Leme, and C. T. Sousa, "Langley method applied in study of aerosol optical depth in the Brazilian semiarid region using 500, 670 and 870 nm bands for sun photometer calibration," *Adv. Sp. Res.*, vol. 54, no. 8, pp. 1530–1543, 2014.

[9] N. Manago, S. Miyazawa, Bannu, and H. Kuze, "Seasonal variation of tropospheric aerosol properties by direct and scattered solar radiation spectroscopy," *J. Quant. Spectrosc. Radiat. Transf.*, vol. 112, no. 2, pp. 285–291, 2011.