

Classification of Urban Fine and Coarse Aerosol using Aerosol Robotic Network (AERONET) from January to October 2024 in Penang

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Structured Abstract

Background: Aerosols are tiny particles suspended in the air that strongly influence air quality, visibility, and local climate. This study examines how these particles vary over time and identifies the dominant aerosol types over Penang, Malaysia, between January and October 2024. In recent years, rapid urban development and recurring transboundary haze from biomass burning in Sumatra have contributed to elevated aerosol levels. The objectives of this study are to analyze trends in aerosol variation, to classify fine and coarse aerosols based on their optical properties, and to compare the classification performance between AERONET and MODIS datasets.

Methods: Data were obtained from two main sources: ground-based measurements from the Aerosol Robotic Network (AERONET) and satellite observations from the Moderate Resolution Imaging Spectroradiometer (MODIS). AERONET datasets provided values for Aerosol Optical Depth (AOD) at 5 wavelength like 440nm, 500nm, 675nm, 870nm and 1020nm as well as the Ångström Exponent while MODIS datasets provided values for Aerosol Optical Depth at 2 wavelength like 470nm and 550nm as well as Angstrom Exponent_(AE470-550) to distinguish between fine and coarse particles.

Results: During the study period, daily AOD values ranged from 0.05 to 0.42. Elevated levels occurred in March (0.35–0.42) and September (0.28–0.36), aligning with haze episodes and biomass burning events. AE values ranged between 1.05 and 2.15, with April showing the highest monthly average of 1.95, indicating a strong dominance of fine-mode aerosols. Using AE thresholds (> 1.0 for fine mode and < 1.0 for coarse mode), 83 % of the observation days were classified as fine-particle dominated, while 17 % reflected coarse-mode influence. A comparison between AERONET and MODIS measurements produced a low but positive correlation ($R^2 = 0.0646$) and a Root Mean Square Error (RMSE = 0.0423), demonstrating consistent detection despite spatial differences.

Conclusion: These findings achieve the research aim by providing clear quantitative insight into aerosol variability and classification of aerosol types that influenced in Penang like urban haze and transboundary haze. The combined use of ground-based and satellite data filling a local knowledge gap and supporting future strategies to manage urban haze and air quality.

Keywords: Aerosol Optical Depth (AOD); Ångström Exponent (AE); Urban aerosols; Transboundary haze; Fine and coarse particles.

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