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Estimating Ground-Level Particulate Matter (PM) Concentration using Satellite-derived Aerosol Optical Depth (AOD)

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Atmospheric aerosols are strongly associated with adverse human health effects. In particular, particulate matter less than 10 micrometers and 2.5 micrometers (i.e. PM10 and PM2.5, respectively) can cause cardiovascular and lung diseases such as asthma and chronic obstructive pulmonary disease (COPD). Air quality including PM has typically been monitored using station-based in-situ measurements over the world. However, in situ measurements do not provide spatial continuity over large areas. An alternative approach is to use satellite remote sensing as it provides data over vast areas at high temporal resolution. The literature shows that PM concentrations are related with Aerosol Optical Depth (AOD) that is derived from satellite observations, but it is still difficult to identify PM concentrations directly from AOD. Some studies used statistical approaches for estimating PM concentrations from AOD while some others combined numerical models and satellite-derived AOD. In this study, satellite-derived products were used to estimate ground PM concentrations based on machine learning over South Korea. Satellite-derived products include AOD from Geostationary Ocean Color Imager (GOCI), precipitation from Tropical Rainfall Measuring Mission (TRMM), soil moisture from AMSR-2, elevation from Shuttle Radar Topography Mission (SRTM), and land cover, land surface temperature and normalized difference vegetation index (NDVI) from Moderate Resolution Imaging Spectroradiometer (MODIS). PM concentrations data were collected from 318 stations. A statistical ordinary least squares (OLS) approach was also tested and compared with the machine learning approach (i.e. random forest). PM concentration was estimated during spring season (from March to May) in 2015 that typically shows high concentration of PM. The randomly selected 80% of data were used for model calibration and the remaining 20% were used for validation. The developed models were further tested for prediction of PM concentration. Results show that the estimation of PM10 was better than that of PM2.5 for both approaches. The performance of machine learning random forest was better (R2=0.53 and RMSE=17.74μm/m3 for PM10; R2=0.36 and RMSE=26.17 μm/m3 for PM2.5) than the statistical OLS approach (R2=0.13 and RMSE=23.66μm/m3 for PM10; R2=0.09 and RMSE=27.74 μm/m3 for PM2.5). However, both approaches did not fully model the entire dynamic range of PM concentrations, especially for very high concentrations, resulting in moderate underestimation.