Dust in the Great Plains and Northern Rockies: Trends and Influences from Land Use

Climate change combined with anthropogenic land use is altering the U.S. landscape, allowing for increases in windblown dust. Increased dust influences the earth system via radiative effects both in the atmosphere and on snow, soil fertility and desertification, and modification of cloud characteristics and microphysics. At the same time, dust increases influence society due to the effects on human health, visibility, and air quality regulated by federal standards. Combining coarse mode aerosol observations from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor aboard the Terra satellite, along with the Aerosol Robotic Network (AERONET) and Interagency Monitoring of Protected Visual Environments (IMPROVE) aerosol monitoring network, trends in dust loading in the United States, specifically from 90°W to the West Coast covering the Great Plains through the Western U.S., are investigated. Analysis of MODIS reveals significant increasing trends throughout the Great Plains and Northern Rockies, reaching 5% increases in Aerosol Optical Depth during dust events (AOD\textsubscript{dust}), for observations when the Ångström Exponent (AE) is less than 0.75, per year between 2000-2018.

Strong increasing trends are revealed in 90th quantile coarse mode observations from AERONET and IMPROVE in the lower Great Plains region. Analysis of the Cropland Data Layer reveals between 5-10% increases in cropland coverage over the majority of the Great Plains. Positive monthly trends in IMPROVE and AERONET coarse mode 90th quantile observations during March, June, and October mirror the spatial pattern of these increases in cropland coverage and coincide with planting and harvesting seasons of corn, soybeans, and winter wheat.

In the Northern Rockies, an oil and gas well dataset for federal and private lands was employed to identify rapid expansion of oil and gas development between 2000-2018 in Colorado, Wyoming, Montana, and South Dakota. The annual frequency of MODIS AOD\textsubscript{dust} observations is positively correlated with each state’s annual frequency of wells drilled. Furthermore, these positive, statistically significant correlations spatially resemble oil and gas development in these states and trends in MODIS AOD\textsubscript{dust} observations during the same time period.

These findings demonstrate the rate of increasing dust loading in the Great Plains and Northern Rockies region and suggest these increases are indeed related to rapid agricultural expansion and oil and gas development. Environmentally Protection Agency (EPA) standards on air quality are being exceeded more frequently within this region. For example, in Kansas and South Dakota, exceedances have moved from never occurring in 2000-2009 to occurring once every 2 to 3 years in 2010-2018 averaged over monitoring sites, which brings sites in those states into non-compliance. In the Great Plains and Northern Rockies, where the influence of climate change on drought is highly uncertain, policy changes related to these methods of land use may be imperative to avoiding the risk of regional scale desertification and negative effects on human health and environmental resources.

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