4.023 Unraveling the influences of pollution and climate trends on radiation fog frequency using generalized additive models.

Early Career Scientist

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Abstract:

Fluctuating trends in dense fog frequency remain a puzzling global phenomenon. In California's Central Valley, episodes of radiation fog increased as much as 92% from 1930-1970, followed by a 76% reduction since 1980. The dominant hypothesis suggests that the decline in fog can be explained by rising temperatures associated with climate change. We instead assert that changes in air pollution better explain California's historical upward-then-downward fog trend. As unregulated emissions increased pollution from 1930-1970, it directly contributed to the CCN formation necessary to create clouds and fog. With emission mitigation in the 1970s, pollutant concentration declined rapidly, thus reducing the CCN available for fog formation. Similar radiation fog trends have been observed in Italy's Po Valley – a location of comparable climatology and anthropogenic function – where a 50% fog reduction has also been observed over the past 40 years, concurrent with dramatic improvements in air pollution.

To identify the most significant variables affecting visibility, an indicator of dense fog, and compare the trends in these two analogous regions, we used a generalized additive model (GAM) to test the predictor variables (temperature, wind speed, dewpoint, sea level pressure, precipitation, and pollutant concentration). We ran the model for a range of sites in California and Italy with differing timescales (daily, monthly, annual, decadal) to elucidate the nonlinear relationships in the system. Over 60% of the variance was consistently explained by dew point depression, wind speed, pollution concentration, and precipitation. Trends in dewpoint depression, which incorporates both water availability and temperature, have greater influence on daily time scales, suggesting that short-term fog meteorology is primarily influenced by local weather patterns. The explanatory value of pollution concentration becomes more pronounced when analyzing on annual timescales, where CCN's influence on the probability of fog climatology is most clearly expressed independent of year-to-year meteorological variance.