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The mechanisms and meteorological drivers of the ozone-temperature relationship

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Surface ozone (O_3) pollution levels are strongly correlated with daytime surface temperatures, especially in highly polluted regions. This correlation is nonlinear and occurs through a variety of temperature dependent mechanisms related to O_3 precursor emissions, lifetimes, and reaction rates, making the reproduction of temperature sensitivities – and the projection of associated human health risks – a complex problem.

Here we explore the summertime O_3-temperature relationship in the United States and Europe using the chemical transport model GEOS-Chem. We remove the temperature dependence of several mechanisms most frequently cited as causes of the O_3-temperature "climate penalty", including: PAN decomposition, soil NO_x emissions, biogenic VOC emissions, and dry deposition, and quantify the contribution of each mechanism to the overall correlation between O_3 and temperature. We find that the thermal decomposition of PAN can explain, on average, 20% of the overall O_3-temperature correlation. The effect is weaker in Europe, explaining 9% of the overall O_3-temperature relationship. The temperature dependence of biogenic emissions contributes 3% and 9% of the total O_3-temperature correlation in the United States and Europe on average, while temperature dependent deposition (6% and 1%) and soil NO_x emissions (10% and 7%) also contribute. Even considered collectively these mechanisms explain less than 46% of the modeled O_3-temperature correlation in the United States and 36% in Europe. We use commonality analysis to demonstrate that covariance with other meteorological phenomena such as stagnancy and humidity explains the bulk of the remainder of the O_3-temperature correlation.