The Influence of Climate Change on Future Global Air Quality using GCAP2.0

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Abstract

Climate change can impact on air pollutant concentrations and human health, especially Ozone (O_3) and fine particulate matter ($PM_{2.5}$) and through meteorology, particularly temperature and precipitation. Global Change and Air Pollution (GCAP2.0), which is a one-way offline coupling between the NASA-GISS version 2.1 general circulation model (GCM) and a global 3-D Chemical-transport model (GEOS-Chem) are used in this study to fill the gap of investigating how changes in future climate may affect global air quality in the future by CTMs. Anthropogenic emissions are held constant at 2015 levels to isolate climate-induced changes to simulate the concentration of $PM_{2.5}$ including its precursors (i.e., Sulfate, Nitrate and Ammonium; SNA) and Ozone changes under SSP1-2.6 (Low warming), SSP2-4.5 (Intermediate) and SSP5-8.5 (High warming) relative to historical scenario (HIST) for Near-term (2050) and Future-term (2100) periods. Lastly, we investigated human health contributed by climate change using exposure model to identify the health benefits associated with those concentration changes. Overall results show a decrease in $PM_{2.5}$ concentrations in the near-term (2050) period across all scenarios (SSP1-2.6: -0.29 μg/m^3, SSP2-4.5: -0.16 μg/m3, SSP5-8.5: -0.13 μg/m^3). However, in the future-term (2100), only SSP1-2.6 exhibits a decrease (-0.3 μg/m^3), while SSP2-4.5 and SSP5-8.5 show increases (+0.15 μg/m^3 and +0.33 μg/m^3, respectively). Ozone concentrations notably increase under SSP5-8.5, driven by temperature rises, with an approximate +0.4 ppbv change. Changes in $PM_{2.5}$ and SNA, and Ozone are sensitive to seasonal variations, especially in Autumn (SON) and Spring (MAM), due to temperature and precipitation changes. Health impacts associated with climate-induced $PM_{2.5}$ and ozone variations suggest heightened risks, particularly in scenarios with higher warming. SSP5-8.5 exhibits the most significant adverse effects, potentially leading to elevated respiratory and cardiovascular issues. Thus, this research highlights the “Climate penalty on air quality,” indicating that future climate changes significantly influence air pollution levels.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon, CATCH: the Cryosphere and Atmospheric Chemistry, AMIGO: Analysis of eMIssions usinG Observations, GEIA: Global Emissions Initiative, CCMi: Chemistry Climate Model Initiative, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality, PACES: Air Pollution in the Arctic: Climate, Environment, and Societies, TOAR: Tropospheric Ozone Assessment Report, BBURNED: Biomass Burning Uncertainty: ReactioNs, Emissions and Dynamics, Allin-Wayra: Small Sensors for Atmospheric Science

IGAC Regional Working Groups

Japan National Committee, MANGO: Monsoon Asia and Oceania Networking Group